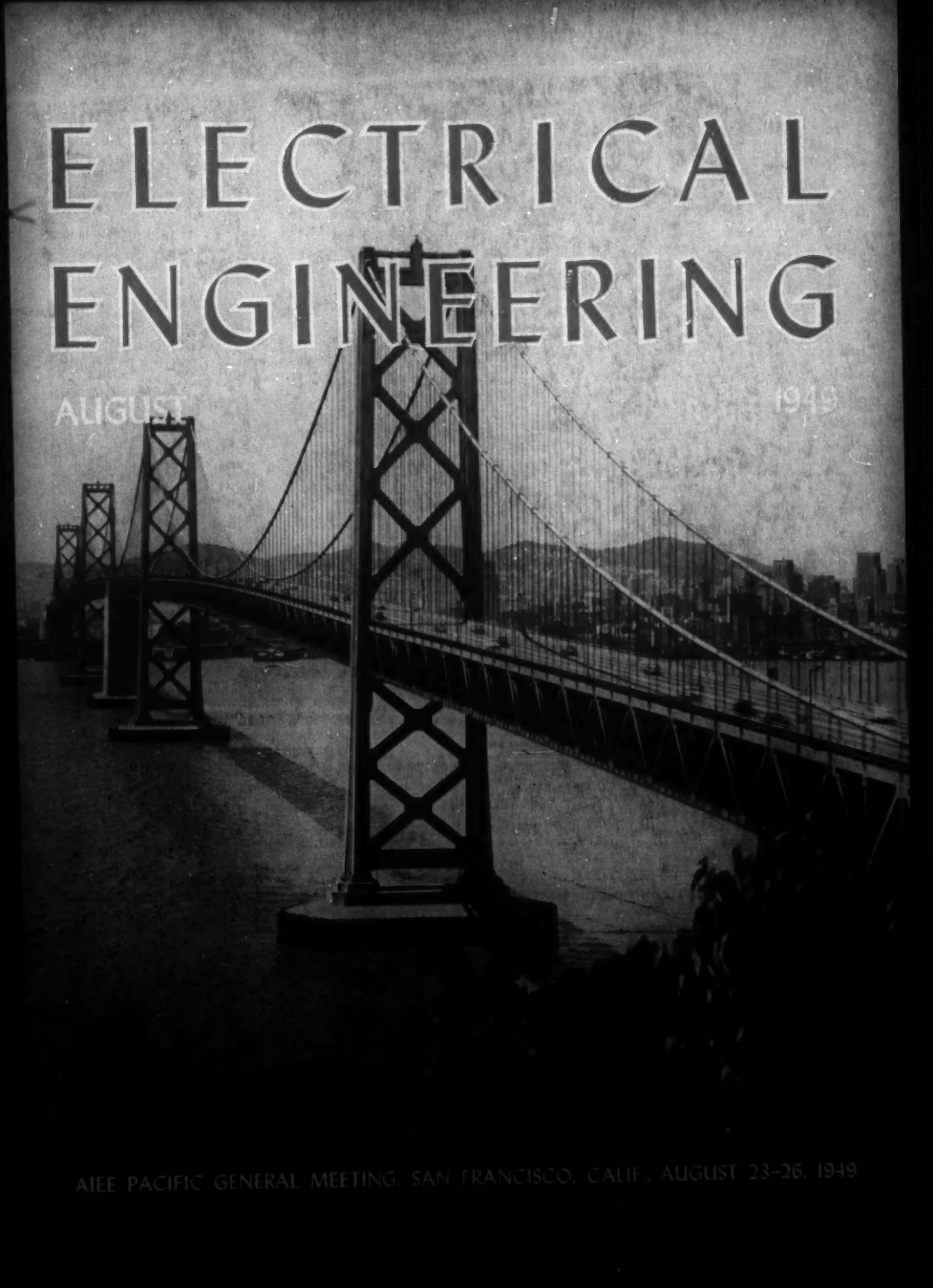
ELECTRICAL ENGINEERING

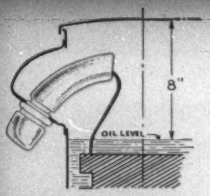
AUGUST 1949



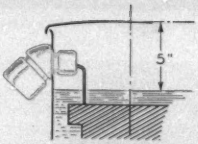
AIEE PACIFIC GENERAL MEETING, SAN FRANCISCO, CALIF., AUGUST 23–26, 1949

NOW...

- *Tank Height Reduced!*
- *Bushing Pockets Eliminated!*
- *Bushing Clamp Simplified!*



OLD DESIGN required more space above oil level because of longer bushing shank.



NEW BUSHING saves up to 3" in tank height . . . eliminates need for bushing pockets.

EXPLODED VIEW shows the simplicity of the new bushing clamping arrangement.

A-2704

. . . on Allis-Chalmers Distribution Transformers

ALLIS-CHALMERS NEW TANK-WALL BUSHING eliminates all need for high voltage bushing pockets . . . enables up to 3" reductions in tank height. This means even greater compactness . . . easier handling distribution transformers than ever before! (Reductions are *in addition* to savings in size and weight through use of highly oriented core steel.)

Installation of the bushing itself is simplified because there are fewer parts, and no critical porcelain tolerances between bushing and keeper. A cushion-like spring on the inner side of the tank wall, between the keeper and bushing absorbs any shock or strain during handling. Increased wall thickness of the bushing, together with straighter, shorter shank contour, increases mechanical strength.

AVAILABLE ON UNITS UP TO 150 KVA

The new design is available on transformers from 3 to 100 kva, single phase, and from 9 to 150 kva, three phase, in voltages up to 4800/8320Y.

For further details on this new bushing, or for other facts on Allis-Chalmers quality distribution transformers, call your nearby A-C sales representative.

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ALLIS-CHALMERS

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ELECTRICAL ENGINEERING

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AUGUST
1949

The Cover: San Francisco Bay Bridge, taken from Yerba Buena Island. San Francisco, site of the AIEE Pacific General Meeting, August 23-26, is glimpsed in the distance. Union Pacific Railroad photo

Highlights (including News Index) . . . 3A

Power Electronics as an Educational Medium — C. H. Willis . . . 647

Postwar Planning for High-Voltage Transmission in Northern California — W. R. Johnson . . . 650

An Automatic Test Board for Small Motors — S. S. Wolff . . . 655

Registered Professional Engineers — R. W. Sorensen, A. H. Lovell . . . 659

The Amplistat—A Magnetic Amplifier — R. E. Morgan . . . 663

Vladimir Kosma Zworykin—Lamme Medalist for 1948

The Lamme Medal — Nelson S. Hibshman . . . 668

The Medalist's Career — David Sarnoff . . . 669

Engineer's Role in the Progress of Science — Vladimir K. Zworykin . . . 670

Proposed Frequency Band Designations — AIEE Committee Report . . . 672

Electrolytic Zinc Plant — Joseph S. Bowman . . . 673

Summer Meeting Conference Paper Digests . . . 679

Miscellaneous Short Items:

An Electric Bridge De-icer, 649; Color Television Used in Testing Supersonic Engine, 662; Measuring Wear in Textiles, 667; Television Applications, 676; Electrical Essays, 677

Institute Activities . . . 692

AIEE Personalities, 707; Obituary, 708; Membership, 709

Report of the Board of Directors . . . 718

Of Current Interest . . . 744

Letters to the Editor, 747; Pamphlets, 747; New Books, 748

Industrial Notes . . . 16A

New Products, 20A; Trade Literature, 28A; Index to Advertisers, 52A

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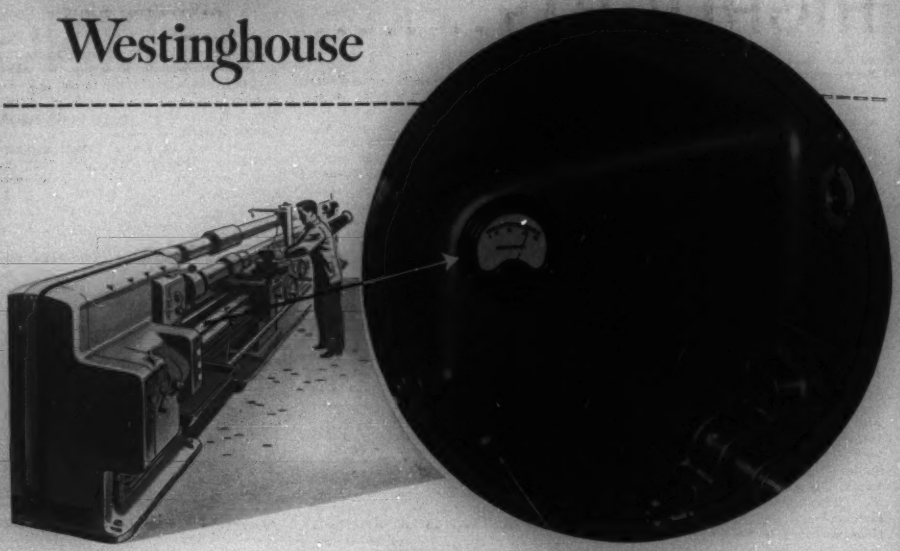

This Westinghouse Instrument helps set *New Production Records*

Savings in machine time up to 75% are common among the users of the American Tool Works Company's new hydraulic duplicating lathes!

A standard feature of these lathes is the Westinghouse horsepower instrument. It shows, at a glance, the horsepower being consumed by the cut. This enables the operator to take full advantage of the capabilities of the machine and to make maximum cuts without overloading. Machines can be easily operated at peak loads, without the dangers of overtaxed motors and damaged cutting tools.

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HIGHLIGHTS .....

Presidents' Messages. Everett S. Lee, AIEE President for 1948–49, selects "Open Doors" as the title of his Summer Meeting address which constitutes his farewell message as President of the Institute. He points out that it is the engineer who opens the doors to new accomplishments, to new advances, to new products, and that the opening of such doors is the engineer's contribution to the progress of the world (*pages 692 and 694*). Incoming President for 1949–50, James F. Fairman, discusses the problem of "Engineering Organization," and pledges his continued support in behalf of some scheme for greater unity of action on matters of common interest to engineers (*page 693*).

Pacific General Meeting. With the Fairmont Hotel in San Francisco, Calif., as headquarters, the AIEE Pacific General Meeting will be held August 23–26. Inspection trips will include the University of California Radiation Laboratory, Station P and Mission Substation of the Pacific Gas and Electric Company, and the United States Naval Shipyard at Hunters Point (*pages 695, 697–8*). A complete program is included (*pages 696–7*).

Summer General Meeting. Attracting a record attendance of 1,650, the 65th AIEE Summer General Meeting was held at the New Ocean House, Swampscott, Mass., June 20–24. Of special interest were the two Conferences of Section Delegates, the first of which was divided into two parts: Section Publicity, and Institute Policy (*pages 698–703*). The 30 technical sessions held during the meeting covered a wide range of topics, with sessions on power, industry, communications and science, and general applications (*pages 703–04*). Brief authors' digests of most of the conference papers presented at the meeting are included in this issue (*pages 679–91*).

News Index

Institute Activities.....692

Message From President Lee 692
Message From Incoming President Fairman ...693
Pacific General Meeting.....695
Summer General Meeting Held.....698
Future AIEE Meetings.....699
Committee Notes.....705
AIEE Personalities.....707
Obituary.....708
Membership.....709

Of Current Interest.....744

Electrical Utility Employment to Expand.....744
10,000 Engineers to Get Questionnaires.....744
Future Meetings of Other Societies.....744
Letters to the Editor.....747
Pamphlets.....747
New Books.....748

Board of Directors' Report. The Report of the AIEE Board of Directors for the fiscal year ending April 30, 1949, is presented in full in this issue. It includes a brief summary of the principal activities of the Institute during the year, as well as financial statements showing the financial condition of the Institute at the end of the fiscal year, cash receipts and disbursements, and a schedule of securities owned (*pages 718–43*).

Membership Growth. This month's membership listing records more than 2,200 applications for election to AIEE membership (*pages 709–17*). Most of these are from young newly-graduated engineers seeking to transfer from Student membership to full Associate status—youth which the Institute welcomes in its program of vigorous and progressive leadership in the field of electrical engineering.

Lamme Medalist for 1948. The Lamme Medal for 1948 was presented during the recent Summer General Meeting to Vladimir K. Zworykin of the Radio Corporation of America. Full texts of the addresses at the presentation ceremony are given in this issue. These include the history of the Lamme Medal, an account of this year's medalist's career, and Dr. Zworykin's response, "The Engineer's Role in the Progress of Science" (*pages 668–72*).

Frequency Band Designations. A chart prepared through the efforts of the AIEE Joint Technical Committee on Standard Frequency Bands and Designations proposes the use of band designation numbers to indicate frequency ranges over the whole useful range of frequencies which occur in nature, thus giving a single coordinated system (*page 672*).

Registered Professional Engineers. "Registered professional engineers are engineers granted by one or more states the rights and privileges of practicing professional engineering." Presented primarily for the young engineer or engineer-to-be, this article reviews registration laws and requirements (*pages 659–62*).

Testing Small Motors. An automatic test board has been developed which provides a reliable, efficient, and economical method of testing small mass-produced induction motors. Such a board is now in use at the Century Electric Company in St. Louis, Mo. (*pages 655–8*).

Power Electronics in Education. The use of power electronics as an educational medium has not been fully exploited by teachers of engineering although the field offers a great many examples and illustrations which can be used in presenting fundamental theory—and the proper choice of illustrations when teaching such theory well can determine whether a course will be stimulating or dull (*pages 647–9*).

The Amplistat. "The amplistat is a magnetic amplifier using one or more saturable core reactors in such a way as to secure exceptionally high gain." With advantages of long life, no starting delay, no moving parts, and sturdy and quiet operation, its uses are similar to those of thyratrons, amplidynes, and some vacuum tubes (*pages 663–7*).

Electrolytic Zinc Plant. In 1941 and 1942, the American Smelting and Refining Company built an electrolytic zinc plant at Corpus Christi, Tex., to produce high-grade metallic zinc. The plant is divided into eight parts: concentrates storage, roasting, acid, leaching, purification, electrolysis, melting and casting, and power (*pages 673–6*).

High-Voltafie Transmission. In six years, northern California power engineers plan to construct 1,400 miles of 230-kv lines. Coupled with the addition of 1,300,000 kw of generating capacity, this will provide improved service, and will allow the interchange of power between hydroelectric and steam generating plants (*pages 650–5*).

AIEE Proceedings

Order forms for current AIEE *Proceedings* have been published in *Electrical Engineering* as listed below. Each section of AIEE *Proceedings* contains the full, formal text of a technical program paper, including discussion, if any, as it will appear in the annual volume of AIEE *Transactions*.

AIEE *Proceedings* are an interim membership service, issued in accordance with the revised publication policy that became effective January 1947 (*EE, Dec '46, pp 567–8; Jan '47, pp 82–3*). They are available to AIEE Student members, Associates, Members, and Fellows only.

All technical papers issued as AIEE *Proceedings* will appear in *Electrical Engineering* in abbreviated form.

Location of Order Forms	Meetings Covered
Aug '48, p 45A	Great Lakes District North Eastern District Summer General
Oct '48, p 43A	Pacific General Middle Eastern District
Dec '48, p 35A	Midwest General Southern District
Apr '49, p 25A	Winter General (1949)
Jul '49, p 47A	South West District Summer General

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3. Industrial power lines
4. Underground distribution
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8. Municipal signal wiring
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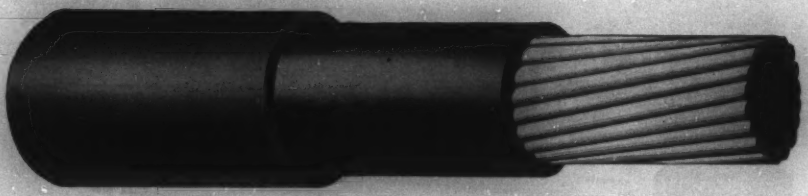

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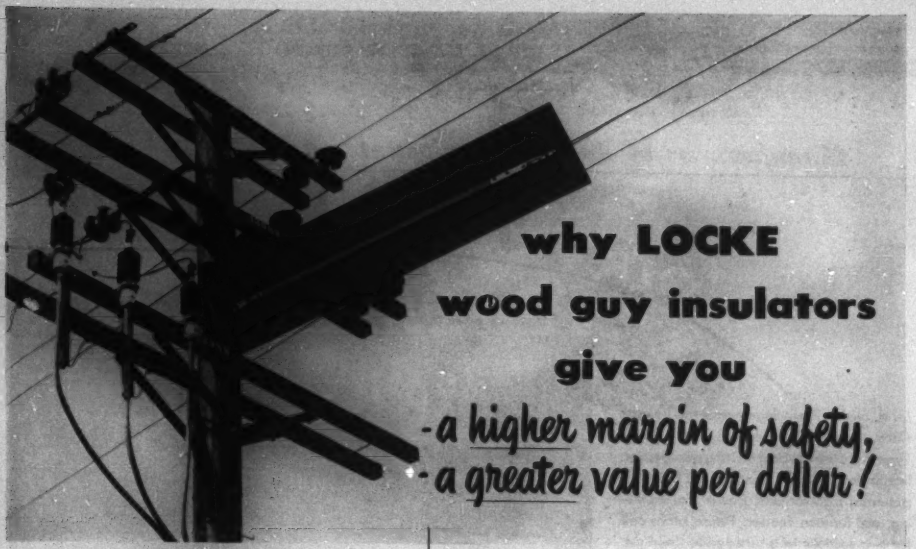

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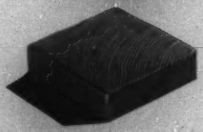

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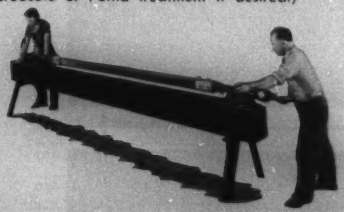
The photograph shows a cross section of a Locke Wood Guy Insulator. Finest Douglas Fir resists rotting and insect infestation — thin, uniform growth rings give highest strength, maximum protection against structural flaws. Quality wood plus greatest cross sectional area give Locke Wood Guy Insulators highest dependability. (Creosote or Penta treatment if desired.)



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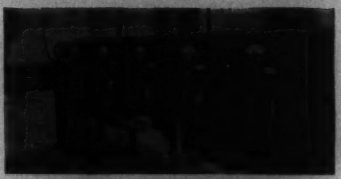
G. H. Slater, Plant Engineer of the Balmar Corp., inspects the General Electric 15-kv Type MI-6 metal-clad switchgear. Section lineup (left to right): incoming line breaker, potential transformers, Power Co. metering, arc furnace feeder. Future plans call for two sections to be added to the right, one to the left, of the existing unit. Note neat appearance of metal-clad unit—it's space saving, too, and the metal-clad construction offers operating safety to personnel. And the three new sections will be added—when they are needed—with a minimum of fuss, bother, and expense.

Door of No. 1 compartment of metal-clad unit swung open showing magne-blast air circuit breaker (1200 amperes, 250,000 kva interrupting rating) in operating position. Magne-blast breakers are designed with adequate "IC" (Interrupting Capacity) for short circuit protection, are easily removed for inspection. Instruments and relays are co-ordinated for positive protection of high-voltage feeders.

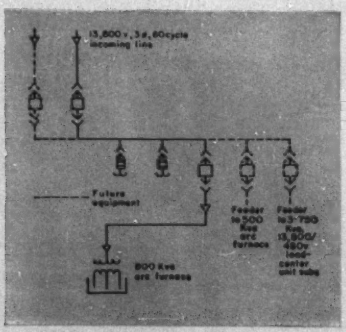
OBSOLETE



OBSOLETE

This old equipment was considered hazardous and deficient for present duties. Note dangerous, "spider-work" construction. Obsolete oil breakers of inadequate "IC" were seriously overloaded; in case of a bad short circuit could have exploded in a shower of flaming oil.

Metal-Clad Switchgear


13,800 v., 3 ø, 60 cycle incoming line
Future equipment
Feeder to 500 Kva arc furnace
Feeder to 3-750 Kva 13,800/480 v load-center unit subs
800 Kva arc furnace

Here's the one-line diagram showing the initial phase of changing over from 25 to 60 cycles at Balmar's Baltimore plant. General Electric 15-kv Type MI-6 metal-clad switchgear handles the incoming 13.8 kv through magne-blast air circuit breakers of 250,000 kva interrupting rating. Future plans call for another incoming line section, plus two more feeders.

The Balmar installation is a complete General Electric project—one source of responsibility, plus the very best in planning, engineering, manufacturing, and servicing facilities to give maximum savings and efficiency to the customer.

SEND FOR THESE HELPFUL BULLETINS

GEA-3083	Metal-clad Switchgear
GEA-4966	Low-voltage Metal-enclosed Switchgear
GEA-3592	Load-center Unit Substations
GEA-3758	Load-center Power Distribution
GEA-4507	Interlocked-armor Cable for Primary Circuits
GEA-4352	Flamenol Cable for Secondary Circuits

—*here's why . . .*

"As a part of our long-range plan of replacing old 25-cycle with new 60-cycle equipment we wanted completely metal-enclosed units to help eliminate danger to operating personnel. Our figures proved it was more economical to purchase a complete unit rather than a 'knocked down' substation. The cost of installing this metal-clad unit was negligible."

G. H. SLATER, PLANT ENGINEER, BALMAR CORP.

The Changeover at Balmar will continue over a period of years. This means only a small part of the total system capacity will be required during the early stages. A problem like this is easily solved with the General Electric load-center power distribution system that Balmar is using—it permits the installation of equipment as it is needed, and allows the over-all program to be accomplished in successive steps. This feature eliminates the necessity for tieing up large amounts of capital in equipment that would not be used to capacity for years to come.

The First Unit Installed was only large enough to handle its own load, plus a nominal margin for continuing the changeover program. As other units are added, this reserve becomes available for normal plant expansion and at no time will there be any large amount of unused capacity.

Modern Industrial Power distribution systems using G-E switchgear and load-center unit substations are applicable to any industrial plant or commercial building where you want full-voltage conditions for top performance of equipment, an extremely flexible setup to take care of expanding or changing loads, adequate short circuit protection, safety to personnel, and low installation and maintenance costs. A complete system, using G-E switchgear and load centers, costs you less than a "piece-meal," makeshift affair.

Investigate Today the many advantages of using General Electric switchgear and load-center unit substations in *your* plant for efficient, flexible power distribution. Contact your G-E sales representative for further information—and write for the helpful bulletins listed at the left. *Apparatus Department, General Electric Company, Schenectady 5, New York.*

GENERAL ELECTRIC

FOR more load

Vol. 6
1949

USE TYPE ML MULTI-LEAD PAPER INSULATED CABLES

● For cable users who desire an increase in the possibilities of emergency cable ratings, with no radical departure from present-day "solid" cable construction, we offer Type ML (Multi-Lead) Cables. This construction consists of three orthodox single-conductor paper-and-lead cables stranded together, without fillers and without any over-all binders, to provide for three-phase distribution.

ADVANTAGES

The use of Type ML Cable attacks the problem of cable overload and of severe load fluctuation from several different angles:

1. The loose assembly of conductors permits them to compensate for expansion in length by *radial* rather than longitudinal movement.

2. The individual lead sheaths, because of their smaller diameter, bend more readily, with less strain, and less danger of cracking due to lead fatigue.

3. In Type ML Cables, as compared to three-conductor cables, the diameters of the lead sheaths are reduced in greater proportion than their thickness. Thus, they are better able to withstand internal pressure without rupture.

HANDLES MORE LOAD—SAFELY

In actual use, Type ML Cable shows a number of advantages: (1) it is possible to operate it at maximum standard temperature ratings or, in emergencies, above these limits without danger of sheath failure; (2) an easier training problem in small manholes; (3) greater ease in making "L" taps and single-phase load diversions; (4) elimination of trifurcating joints for use of single-conductor potheads; and (5) simplicity of installation.

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Power Electronics as an Educational Medium

C. H. WILLIS
FELLOW AIEE

In any course presenting basic theory, an important problem facing the instructor is the choice of illustrations which will stimulate student interest. In this article, which was presented at one of the General Winter Meeting's educational sessions, the author explores the field of power electronics as an educational medium in the teaching of engineering.

THE CHOICE of illustrations to be used in presenting fundamental theory is one of the important problems facing a teacher and this decision well may determine whether his course is stimulating or dull. In engineering the topic chosen should stimulate student interest by presenting a challenging example of the basic principles and laws and, in addition, should represent an important field of engineering application. The opportunity to draw examples and illustrations from the field of power electronics has not been fully exploited by engineering teachers. A few typical samples of the material here available will be presented to demonstrate the fertility of this area.

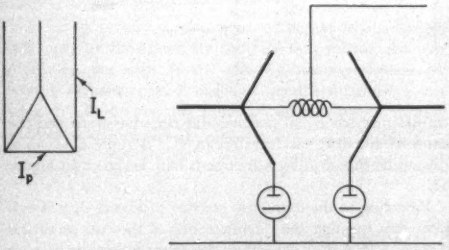

Figure 1. Delta double-Y rectifier circuit

Most elementary texts on a-c circuit theory emphasize problems involving sine waves of current and voltage and tend to produce students with a sinusoidal bias in their point of view. This tendency is exaggerated by the fact that harmonic analysis by the Fourier series may appear to a student as academic and artificial. An oscillograph and a suitable rectifier circuit often will introduce an atmosphere of realism and convince the student of the practical importance of harmonic analysis.

The phase and line currents for a delta double-Y rectifier as shown in Figure 2 for the rectifier circuit of Figure 1 present an especially interesting problem in harmonic analysis. Only the most phlegmatic students are uninterested in discovering that no triplen harmonics are present in the waves shown in either Figure 2*A* or 2*B* and that these two waves have the same harmonic components present in the same proportion with only a phase reversal of alternate pairs to account for the difference in wave shape.

The elusive character of effective values may be emphasized by the circuit of Figure 3. The student must do a careful job of reasoning here to understand why the effective volt-amperes are not equal to the power for a load consisting of two pure resistances, R_1 and R_2, one of which is connected in series with a rectifying device.

The diametric rectifier of Figure 4 provides food for thought when the student discovers that the effective volt-amperes of the transformer a-c or primary winding does not equal the volt-amperes of the d-c or secondary winding. Since both primary and secondary currents are in phase with voltage, the fundamental definitions of power and effective values must be reviewed carefully to discover that the intermittent character of the secondary current causes the apparent contradiction.

This and other rectifier circuits illustrate clearly that all arrangements of equipment are not equally desirable in providing power output. A measure of the effective use of apparatus may be called "apparatus utility" and will be represented by U. Apparatus utility can be defined as maximum output P provided by a given apparatus rating Q:

$$U = P/Q$$

The apparatus utility of a Ward-Leonard drive is some-

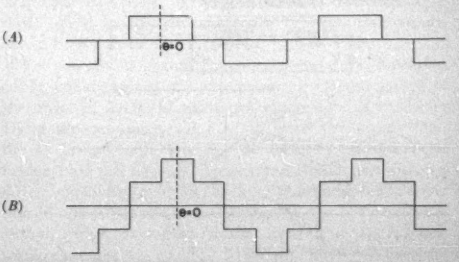

Figure 2. Phase and line currents for delta double-Y rectifier

$$A\text{—}i = \frac{2\sqrt{3}}{\pi} I\left(\cos\theta + -\frac{1}{5}\cos 5\theta + \frac{1}{7}\cos 7\theta - \frac{1}{11}\cos 11\theta + \frac{1}{13}\cos 13\theta \ldots\right)$$

$$B\text{—}i = \frac{6}{\pi} I\left(\cos\theta + +\frac{1}{5}\cos 5\theta - \frac{1}{7}\cos 7\theta - \frac{1}{11}\cos 11\theta + \frac{1}{13}\cos 13\theta \ldots\right)$$

Full text of a conference paper, "Power Electronics as an Educational Medium," presented at the conference on education in power electronics held during the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1949.

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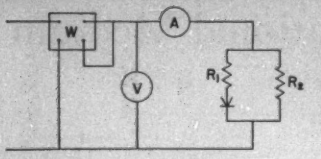

Figure 3. Metering a load consisting of pure resistance in series with a rectifying device

thing less than one-third and the apparatus utility of an autotransformer is greater than unity. The apparatus utility of all rectifier transformers is less than unity, but different rectifier circuits vary greatly in this respect and they offer an excellent opportunity to emphasize this important aspect of power installations.

The most difficult problems connected with power electronics arise in connection with transformer saturation caused by unbalanced rectifier operation. A simple instance of this may be illustrated with the rectifier circuit of Figure 5 which represents a half-wave rectifier supplied through a one-to-one transformer. Two shunts of equal resistance S_1 and S_2 are connected as shown so that the voltage across the two shunts (connection to alternating current) gives the sum of the primary and secondary currents which is the magnetizing current since primary and secondary load components of current are equal and oppositely directed. An oscillograph across alternating current gives a starting transient as shown in Figure 6 when the switch K is closed.

The d-c saturation of the transformer may be explained clearly by considering the hysteresis loop in connection with the curves of current, voltage, and flux as shown in Figure 6.

The intermittent load current flowing through R_1, the resistance of the supply circuit, results in an unsymmetrical voltage as shown by the full line curve in Figure 6*B* which is impressed on the transformer. The flux in the transformer which is assumed to be a symmetrical sine wave before the switch K is closed is represented by the curve 6*C*. The flux, which is the time integral of the voltage curve 6*B* from Faraday's law:

$$\phi_2 - \phi_1 = \frac{1}{N}\int e\,dt$$

must be reduced, each cycle by an amount greater than it increases because the positive area of the voltage wave is less than its negative area as shown in Figure 6*B*. This results in a gradual drift of the flux, cycle by cycle, in the negative direction as shown in Figure 6*C*. As a consequence of this increasing negative flux the magnetizing current required to produce the negative flux increases rapidly because of saturation as shown in Figure 6*D*. This dissymmetry in the magnetizing current is opposite to the dissymmetry in the load current, and when these two dissymmetries are equal the primary voltage impressed on the transformer has equal positive and negative areas and the cause of flux drift has been removed. A representation of this cyclic flux drift by a hysteresis loop is shown in Figure 6*E*.

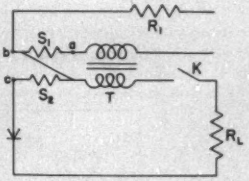

Figure 5. Circuit for observing transformer saturation

Referring to the diametric rectifier of Figure 3, it is evident that opening the circuit to one of the two rectifying devices H or K does not reduce the primary current because the magnetizing current increases to compensate for the component of load current removed. In fact, the magnetizing current which has an average dissymmetry to compensate for the load current is more sharply peaked than the load current and therefore opening one rectifier in Figure 3 results in a considerable increase in the effective value of the primary current and may result in overheating the transformer at half output as a half-wave rectifier.

An interesting example of the effect of saturation on transformer operation is given in the circuit of Figure 7 which represents a transformer T supplying a half-wave rectifier as shown. The resistance of the supply circuit and transformer primary is represented by R_1. The resistance R_2 and the rectifier K are added to reduce transformer saturation. The transformer may be assumed to have a magnetizing current I_m when the secondary circuit is open. The reader is presented the interesting problem of finding the value of R_2 in terms of R_1, R_L, and the transformer ratio α which will prevent transformer saturation and therefore result in a minimum primary current. The rectifiers may be idealized by assuming that they conduct freely in one direction and are perfect insulators in the other. It will be found convenient to analyze the problem in terms of average or instantaneous current values.

The few problems here presented are representative of

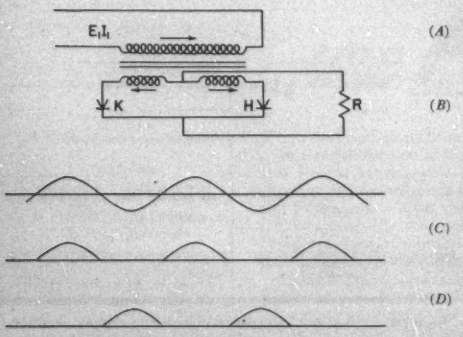

Figure 4. Diametric rectifier circuit and currents

A-c winding volt-amperes $= E_1I_1$; *d-c winding volt-amperes* $= \sqrt{2}E_1I_1$

A—Circuit diagram *C—D-c winding current rectifier K*

B—A-c winding current *D—D-c winding current rectifier H*

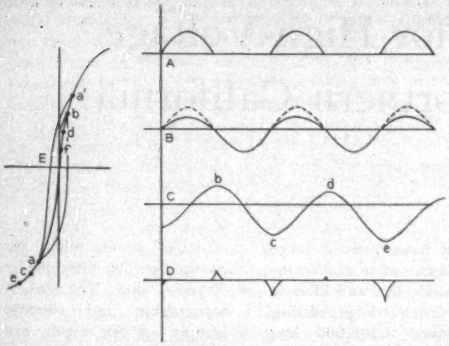

Figure 6. Saturation of transformer because of unbalanced load current in rectifier

A—Load current
B—Transformer voltage
C—Flux
D—Magnetizing current
E—Hysteresis loop

those met in rectifier applications. The importance of this field may be illustrated by the fact that during the war about ten per cent of the kilowatt-hours generated by central stations passed through rectifiers before being utilized. This represents a load of considerable magnitude

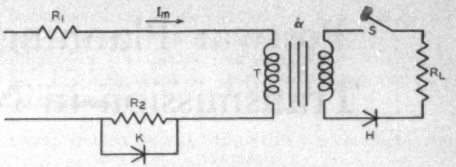

Figure 7. Compensating rectifier and resistor to reduce transformer saturation

and requires a number of engineers for both manufacturing and operation. The number of men with engineering training is inadequate and many college graduates have not been introduced to polyphase rectifier circuits.

There is a strong feeling among those connected with the rectifier industry that the engineering schools should place more emphasis on polyphase rectifiers and the associated circuits.

The material available would easily justify a full term course. This solution may be difficult in view of the already crowded curricula. A more readily attainable solution is to introduce rectifier circuit problems into a-c circuit analysis and to devote a part of the course on a-c machinery to polyphase rectifiers and the associated circuits. Certainly some emphasis of this material is needed in electrical engineering curricula.

An Electric Bridge De-icer

Electric current, flowing in cables buried below the surface of the concrete roadway, will keep Brooklyn Bridge free of snow and ice in future winters, if New York authorities adopt the proposal of Robin Beach, head of Robin Beach Engineers Associated, Brooklyn, N. Y. The renovation of the famed Manhattan–Brooklyn artery, so that it will accommodate six lanes of traffic, now is being planned. According to Mr. Beach, electric heat can remove snow and ice from the bridge as fast as it appears on the road surface. Therefore, he suggests that the installation of heating cable be a part of the program.

It is reported that the bridge's traffic lanes will be surfaced with steel-grid-reinforced concrete. Concrete, of course, is a relatively poor conductor of heat, but the steel surface grid would provide an efficient metallic conducting network for distributing the heat right at the roadway surface, where it is desired.

Lead-covered insulated resistance wire would be the heating cable used. It has been utilized successfully in the past for the purpose of clearing eaves and leaders of buildings, sidewalks, and other surfaces of ice and snow.

This heating cable would be embedded in the concrete roadway, and would be connected to operate on 220 or 440 volts. The higher voltage is thought to be more economical, however. The heating elements of the cable can carry as high a load as 25 amperes.

Power cables for energizing the resistance wire could be run along the sides of the bridge, from which connection would be made to the heating cable through appropriate weatherproof outlets. Protective fuse cut-outs similar to those found in conventional home or industrial circuits would be a part of the equipment.

The continuous warming of concrete surface with heating cable would require the application of electric power of the order of 20 to 40 watts per square foot of roadway. Using the maximum value of 40 watts per square foot, the six 10-foot traffic lanes for the 6,000-foot length of the bridge plus the terminal approaches would necessitate a power expenditure of 16,000 kw. Assuming an electric rate of one cent per kilowatt-hour, the cost of heating the entire bridge, including traffic lanes and approaches, would amount to roughly $160 per hour. When the temperature is a little below the freezing point, 20 watts per square foot might be adequate, thus halving the cost.

In operation, the use of the electric heating would be required for a few days per year. The instantaneous removal of the snow as it falls would require only a fraction of the expense now incurred with manual labor.

Postwar Planning for High-Voltage Transmission in Northern California

W. R. JOHNSON
MEMBER AIEE

Topography and climate have proved large factors in the planning of generation and transmission facilities for the Pacific Gas and Electric Company. Steam and hydroelectric generating capacity is being increased 1,300,000 kw; 1,400 miles of new 230-kv transmission lines are to be added to provide improved service to a 90,000-square-mile area.

THE ROLE of electric power transmission in making possible present-day far-flung power systems is so well known that it requires no restatement. It is to be noted, however, that the design of the transmission system is to a large degree a distinct and separate part of system planning. When new power sources are considered, both steam and hydroelectric, and at various locations, it is the transmission planning which places all upon a common denominator in relation to the load to be supplied.

By properly designed transmission the amount of spinning reserves necessary is held to a minimum; the quality and continuity of service is improved, and new generation is given an efficient outlet.

The postwar construction program of the Pacific Gas and Electric Company includes nearly 1,300,000 kw of new steam and hydroelectric generating capacity. Very extensive additions to the transmission system are required to convey energy from these new plants to point of use. Approximately 1,400 miles of 230-kv circuit have been planned for construction in the period 1946 through 1951, as well as substantial amounts of lower voltage lines. Existing substations are being enlarged; new ones are being built. New engineering problems of reactive supply and control, of greatly increased circuit-breaker interrupting duties, and of high-speed relaying present themselves.

At a time of such extensive transmission system additions, it is appropriate to examine the program, the planning procedures, and the problems to be solved. The purpose of this article is to review the background of this present development, to discuss the planning for the current expansion program, to examine engineering features of the transmission system, and to suggest the direction of future trends.

PACIFIC GAS AND ELECTRIC COMPANY SYSTEM

The Pacific Gas and Electric Company is the major producer and distributor of electric power in northern and central California. The service area comprises a territory of 90,000 square miles, approximately 500 miles long by 200 miles wide. The unusual topographic and climatic features of this region are to be noted because of their effect upon the location and character of electric load, the location of hydroelectric generating sources, and the design of the area's transmission system.

The heart of this region is the great valley of the Sacramento and San Joaquin Rivers—18,000 square miles of rich agricultural land. This valley is surrounded almost entirely by mountains, with the only drainage of its tremendous watershed through the Golden Gate into the Pacific Ocean. The Coast mountain ranges are high enough to screen the inland valley from the heavy storms sweeping in from the Pacific Ocean, tempering the valley's climate but, at the same time, depriving it of adequate rainfall to support the intensive agricultural economy for which the soil is so well suited. These same storms, however, pass on to beat upon the higher slopes of the Sierra Nevada, depositing their store of moisture in the form of heavy snows and rainfall. From the run-off of this precipitation numerous streams are fed, descending the gradual western slopes of the Sierra, producing many favorable hydroelectric sites, and feeding the irrigation ditches and underground waters which make possible the highly developed farming activity in the valley.

All of the rainfall of the region comes during the period from November through the middle of May. During the remainder of the year scarcely a drop of rain falls, except on the higher mountain levels and along the northern coastal section. A further peculiarity of climate, of great importance to the transmission-system designer, is the low incidence of thunderstorms, ranging from about ten storm days per year in the Sierra foothills down to one along the coast.

The population of the Pacific Gas and Electric Company service area increased gradually during the decade 1930 to 1940, but during the war years and especially since 1945, the influx of new population has been rapid. By 1950 it is estimated there will be five million inhabitants in the area, engaging in mining, lumbering, fishing, farming, manufacturing, and commercial activities.

The effects of industrialization, highly electrified farming, and unusual climatic conditions combine to produce two periods of annual peak electric load of approximately

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W. R. Johnson is in the Division of Hydroelectric and Transmission Engineering of the Pacific Gas and Electric Company, San Francisco, Calif.

equal magnitude. The winter peak occurs in the evening as a result of lighting and industrial load, while the summer peak occurs in the late morning hours and is caused principally by the heavy irrigation pumping load in the Sacramento, and especially the San Joaquin, valleys.

In 1948 the summer peak load for the area was 2,128,900 kw, as compared to 2,121,000 kw for the December peak. Had it not been for daylight saving time, the winter peak would have been substantially higher.

The growth of electric load to some extent has paralleled population growth. Before the war the rate of load increase was approximately six per cent, but during the war period growth was accelerated. While it was commonly anticipated that a return to prewar trends would occur following the cessation of hostilities, this assumption proved to be wrong. Although there was some slackening in rate of growth in 1945 and 1946, the peaks for 1947 and 1948 represented increases of 13 and 7.5 per cent over their respective preceding years.

To meet the exceptional load growth requirements, since the war approximately 1,300,000 kw of additional generating capacity is being added to the Pacific Gas and Electric Company system, while during the same period it is expected that the United States Bureau of Reclamation will bring into operation 300,000 kw more of hydroelectric capacity at the Shasta and Keswick projects. The Pacific Gas and Electric Company hydroelectric plants, and those belonging to other producers in the area, are scattered along the western slopes of the Sierra. In wet years the bulk of the energy supply comes from these hydroelectric sources, but during dry years the available energy is 25 to 30 per cent deficient from these plants, and steam capacity must be operated on base load to meet area requirements. The steam plants are located principally in the metropolitan areas of the San Francisco Bay region, and in the lower San Joaquin Valley.

Figure 1 is a map of this area, including such features as plant location, principal cities, and the main transmission circuits. Circuits shown as dotted lines either have been constructed or are planned for construction in the postwar period 1946 through 1951. The main bulk power transmission is at 230 kv, with strong ties at 165 and 115 kv. The subtransmission network of 60 and 69.5 kv is not shown.

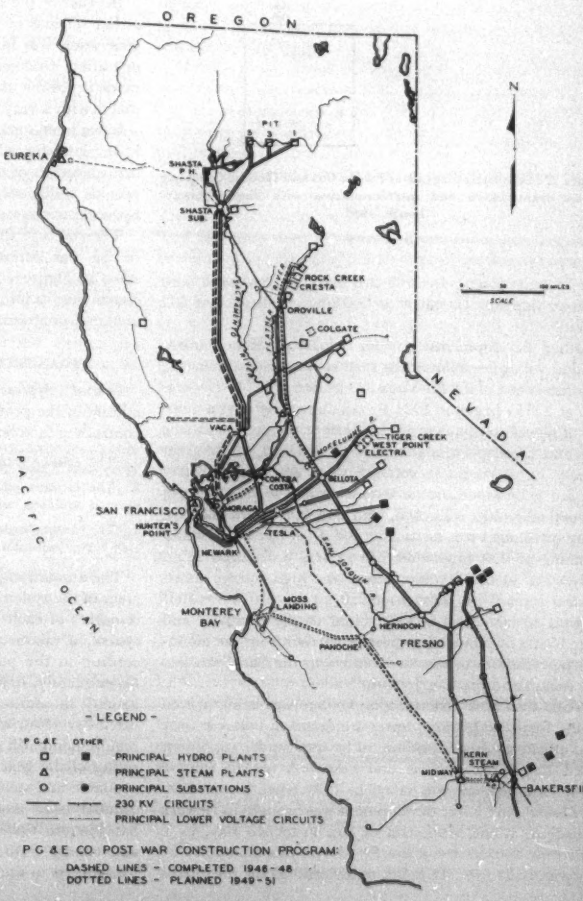

Figure 1. Principal power generation and transmission facilities in northern and central California in 1948, and Pacific Gas and Electric Company planned addition through 1951

DEVELOPMENT OF THE HIGH-VOLTAGE TRANSMISSION SYSTEM

The beginning of electric power supply facilities in northern California dates from the construction of a small steam-electric station in San Francisco in 1879, and from the first hydroelectric plant at Folsom in 1895.[1] Power from Folsom was transmitted at 11 kv some 22 miles to Sacramento, connecting to a small steam plant there. By 1899 the Colgate hydroelectric plant also had been constructed; it was interconnected at Sacramento by a 40-kv

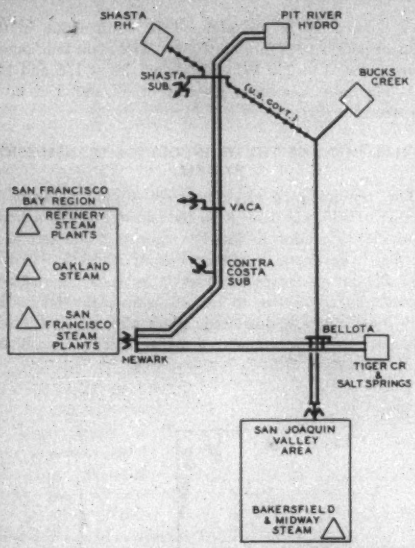

Figure 2. Schematic diagram of Pacific Gas and Electric Company 230-kv transmission and interconnection with Shasta powerhouse, 1946

line 76 miles long. In 1901 this plant was enlarged, and a 60-kv line was extended to Oakland, a distance of 142 miles.

Other developments—greater capacity, higher transmission voltages—followed in swift succession, culminating in construction of the Pit-Vaca 220-kv line in 1921. (Operation at 220 kv began in 1923.)[2] In these early days a number of power companies, predecessors of the present Pacific Gas and Electric Company, entered the field, and a great variety of transmission voltages were employed. There still are to be found on the system distinct levels of 17, 22, 33, 60, 69.5, 100, 115, 165, and 230 kv. With such an array of voltages it is fortunate, and a tribute to the sound planning of that time, that 220 kv was introduced at an early stage in the development of the high-voltage transmission system. A voltage of 220 kv (or 230 kv as it is referred to hereafter) is well suited to the distances and large blocks of power that must be carried from the mountain powerhouses to the load centers in the San Francisco Bay region and the San Joaquin Valley.

While the 230-kv transmission voltage was being proved by the final test of time, lower transmission voltages were used effectively, and continue to be used under conditions suited to their capacities and costs. A second step of 230-kv transmission was taken in 1931 when power from the Mokelumne River development was brought to Newark substation, at the south end of San Francisco Bay, by a 106.5 mile double-circuit line.[3] Also at this time a 230-kv line was built from Oroville southward along the Sierra foothills to a termination at Herndon substation just north of Fresno. Only part of this line initially was operated at the design voltage.

Other extensions of the 230-kv system took place in the period 1944–45 when the Pit River number 5 project came into operation with 146,000-kw capacity, and when the Federal Government completed installation of the first two units at Shasta Dam with 150,000-kw nameplate rating. Two short taps connected the Pit River number 5 plant to the existing lines. The government constructed a single-circuit wood-pole line looping into Shasta substation and extending on to Oroville. Here a connection was made to the existing Pacific Gas and Electric Company line, of 230-kv construction but previously operated at 165 kv. No other lines were constructed from the power producing area; a new 230-kv line was provided between the Vaca and Newark terminal stations, utilizing new construction and an existing line.

Because of the heavy loading of these various circuits a radial scheme of operation was employed, in which the generation was in effect synchronized at the load. This operating arrangement, a wartime conservation measure, made it possible to transmit successfully the output of these plants with a very minimum of new line construction.

Since interruption of any of these radial circuits resulted in the loss of a substantial block of generation, one of the first objectives of the postwar construction program was to provide additional transmission capacity from this northern hydroelectric area.

The status of the 230-kv transmission system at the end of the war period is shown schematically in Figure 2. Also, in Figure 1 the solid lines indicate the transmission system just prior to commencement of the postwar construction program.

TRANSMISSION PLANNING PROCEDURES

General Approach. In planning transmission system additions, the problem may be viewed in the light of three controlling factors:

1. The existing transmission system.
2. The location, character, and amount of existing generation, planned additions, and possible future additions.
3. The existing loads to be supplied; their location, shape of annual load curve, and estimated future trends.

The amount of power to be transmitted between various areas of the system is determined by study of the loads and resources of each area. The power supply of the Pacific system, a mixture of steam and hydroelectric, varies according to the pattern of precipitation and stream flow. Consequently, dry, average, and wet years require investigation; in addition seasonal variations must be considered carefully. Not infrequently the determining transmission requirements will occur during the light-load period in the spring of the year when maximum hydroelectric power is available and steam generation is at a minimum. In the summer large amounts of energy must be routed to the San Joaquin Valley; in winter this load is greatly reduced, and energy from the same generating sources must be transmitted to the San Francisco Bay region.

A comparison of the interarea transmission requirements with the existing transmission capacities between these same areas indicates additional requirements. A tentative program of new lines and substations then may be formulated. Based upon experience on the Pacific system, these objectives are given consideration at this stage:

1. Extend the high-voltage lines as close to major load centers as practicable.

2. Supply main substations by lines over separate routes.

3. Attempt to avoid greatly increasing circuit-breaker interrupting duties on existing stations.

4. Provide adequate electric ties between parts of the system to insure stable operation following transient disturbances.

5. Obtain the desired results by simple step-by-step additions and alterations to the existing facilities, and yet provide a complete and workable system after each step.

The most promising transmission schemes are set up on the a-c network calculator and are checked, investigated, and usually revised. A great deal of specific information is obtained from the network calculator study: transformer bank sizes and tap range requirements; stability limits; circuit-breaker interrupting duties; reactive supply and control requirements; and maximum circuit loadings.

Specific Design Features. When a definite plan has been developed, it is broken down into its various components of lines and substations for detail engineering design. Whereas the foregoing procedures might apply to any system, the detail design usually is based upon experience and conditions that are frequently peculiar to the area.

For example, the main bulk power transmission on the Pacific system is almost exclusively by double-circuit 230-kv steel-tower lines. The cost of a double-circuit tower line with one circuit strung is only slightly greater than for a single-circuit line; with both circuits strung the double-circuit line costs less than 75 per cent as much as two single-circuit lines. Double-circuit construction is inexpensive and has proved very satisfactory, because the absence of snow and ice loading over most of the territory permits the use of relatively light towers with vertical circuit configuration, and the low isoceraunic level has contributed to a high degree of reliability of the twin circuits.

The double-circuit tower design lends itself readily to effective use of overhead ground wires, but these generally were not used on the earlier construction. More recently, where a new line is built parallel to an existing line or is a major system tie, ground wires have been installed. They also are employed for a short distance on outgoing lines from hydroelectric plants in the mountainous areas, where lightning incidence is higher.

The addition of many miles of high-voltage circuit imposes a problem of reactive supply and control in handling the line charging current during periods of light load. For the approximately 1,400 miles of 230-kv circuit constructed or planned for the period 1946–51, it is estimated the total charging current will be 350 megavars. Based upon past experience, synchronous condensers aggregating 225 megavars lagging capacity will be required to control satisfactorily the voltage when the transmission is lightly loaded. The remaining charging current will be absorbed in system load and line losses, or by generation operating at slightly leading power factor.

When the lines are heavily loaded, a substantial amount of leading reactive supply is required to supply the net reactive loss in the transmission and to correct the load power factor to unity or slightly leading. Part of the line reactive loss is supplied from generation; the remainder, by synchronous condensers or steam plants at the receiving ends of the lines. Past experience has indicated that sufficient leading capacity to correct the load power factor from 90 to 100 per cent is adequate.

The usual hydrogen-cooled synchronous condenser has a lagging capacity of 34.7 per cent of the leading capacity at 15 pounds hydrogen pressure. This proportion of lag to lead has not proved entirely in line with the reactive requirements outlined. In order to increase the capacity in the lagging range, machines equipped with modern excitation systems are operated into the reversed field region, approaching the steady-state pull-out point. A gain of 15 to 20 per cent in the lagging capacity seems feasible by this means.

Other special means of handling line charging current and controlling reactive flow include regulating transformers at some of the major 230/115-kv interconnections, motor-driven synchronous condensers for testing lines, and two installations of shunt reactors.

All synchronous condensers on the high-voltage transmission system are connected to the tertiary windings of 230/115-kv autotransformers, an arrangement successfully used for more than 25 years. Autotransformers are used exclusively for the 230/115-kv transformation because of lower cost, better efficiency, and inherently lower reactance. This latter feature, once a distinct advantage, is no longer of as great significance. In more recent installations emphasis sometimes has been upon higher reactance, because short-circuit interrupting duties on the 115-kv system were exceeding available circuit-breaker interruption capabilities.

In the early stages the 230-kv system was not sufficiently extensive to provide a complete transmission network. Interconnecting 115-kv lines were very necessary to system operation. As the 230-kv system has grown, these 115-kv ties, being less vital, may be normally opened. By this means interrupting duties for 115-kv switchgear are held to 3.5 megavolt-amperes. At the same time the maximum possible short circuits on the 230-kv system are increasing. For the Contra Costa steam plant, now under construction, it is planned to use 3-cycle 230-kv impulse-type circuit breakers rated at 10 megavolt-amperes.

In addition to 3-cycle circuit breakers on recent installations, carrier-controlled distance-type relays are used on nearly all 230-kv circuits to obtain the fastest possible fault clearing time. Installation for high-speed automatic reclosing is being made but is not yet in operation. A selective reclosing arrangement may be used, permitting reclosing only after single phase to ground faults.

POSTWAR CONSTRUCTION PROGRAM

The construction program, now well under way, will bring into operation nearly 1,000,000 kw of steam and

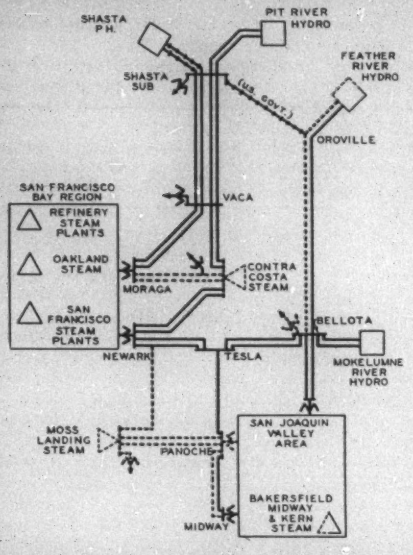

Figure 3. Schematic diagram of Pacific Gas and Electric Company 230-kv transmission and interconnections with Shasta powerhouse, 1948

Proposed additions through 1951 are shown as dotted lines

300,000 kw of hydroelectric capacity. The estimated net generation-capacity increases, either completed or planned for the 1946–1951 period, are shown in Table I.

Table I. Estimated Net Generation-Capacity Increases

Year	Steam, Kw		Hydroelectric, Kw	
1946–47	Two additional units, boilers and improvements to existing plant in the Eureka area (approximate)	12,000	Pit River number 1 forebay peaking increase on existing units	32,000
1948	Kern number 1	75,000	New Electra*	87,000
	Hunters Point	100,000	West Point	13,000
1949	Hunters Point	100,000	New Colgate*	23,000
			Cresta	68,000
1950	Kern number 2	100,000	Rock Creek	110,000
	Moss Landing	100,000	Potter Valley peaking increase on existing units	4,000
1951	Moss Landing	100,000	Total hydro	337,000
	Moss Landing	100,000		
	Contra Costa	100,000		
	Contra Costa	100,000		
	Contra Costa	100,000		
	Total steam	987,000		

* Replaces existing generation at the two plants totaling about 30,000 kw

Along with the additions to generating capacity shown in Table I, more than 1,400 miles of 230-kv circuit and more than 600 miles of 115-kv circuit are planned for construction in the period 1946–51. Of these totals nearly 600 miles of 230-kv and 225 miles of 115-kv circuit have been completed so far. Three new 230-kv substations have gone into operation, and several more are planned, as well as additions to existing installations.

The first major transmission addition completed was the double-circuit 230-kv line from Shasta substation, paralleling the existing line to Vaca-Dixon substation and continuing on to the new Moraga substation in the heart of the eastern San Francisco Bay area. This new line provides an efficient inlet for hydroelectric power from the northern California plants directly to the metropolitan Oakland area with its heavy load of residential and industrial users. The two circuits of this line, operating in parallel with the two previously constructed Pit circuits and the existing government line to Oroville, provide adequate transmission capacity for the Pit River plants and the government plants at Shasta and Keswick dams.

At the Moraga-substation terminus of the line, two 90,000-kva autotransformer banks step down line voltage from 230 to 115 kv. Power is fed out over existing short 115-kv lines to a number of distributing stations located in the various cities in the area. Synchronous condensers are connected to the transformer-bank tertiaries, and regulating transformers on the 115-kv outputs further contribute to a control of voltage and reactive flow in a very flexible manner.

A second important 230-kv transmission addition was completed in 1948 in the southern part of the system. From a new switching station on the existing Tiger Creek–Newark line, a double-circuit steel-tower line skirts the foothills of the Coast mountain range along the edge of the San Joaquin Valley for 202 miles to a new 230-kv terminus at Midway substation near Bakersfield. Only one circuit has been strung on this twin-circuit line.

This new line serves to transmit power from the northern or central part of the system to supply the heavy agricultural pumping load in the lower San Joaquin Valley. It likewise furnishes a strong electric tie from the northern system to the vicinity of the new Kern steam plant near Bakersfield, and provides an outlet to the system for power from this plant when the local area load is light.

At the Midway substation a 75,000-kva autotransformer bank is installed, with a second bank soon to follow. Here also synchronous condensers are connected to the transformer tertiary windings. One of these synchronous condensers is equipped with a driving motor, so that it may be used as a generator to charge and test the 230-kv line. Because the lagging capacity is not sufficient to charge the 202-mile line, two 20,000-kva shunt reactors also are available for use in this operation. Power is fed out from Midway over existing 115-kv lines, and over new 115 kv ties to the Kern steam plant.

A new 300,000-kva steam plant is now under construction at Moss Landing on Monterey Bay, about 100 miles below San Francisco. Part of the output of this plant will be used to supply load in this coastal area by connections to existing 115-kv lines and substations. Full capacity 230-kv outlets also are planned, so that full output of the plant will be available for system needs at all times. A new 230-kv double-circuit line, with one circuit strung initially, will lead northward connecting to the existing system in the San Francisco Bay region; another line will cross the Coast mountain range via the Panoche Pass to the new Panoche substation on the Tesla–Midway line. A second

circuit is planned, on the existing towers, from Panoche to Midway to strengthen this important transmission tie. At Panoche substation a single 100,000-kva autotransformer bank will be installed initially to supply 115-kv lines radiating into the San Joaquin Valley west of Fresno.

A second 300,000-kw steam plant is also under construction, close to the existing Contra Costa substation near the confluence of the Sacramento and San Joaquin rivers. This plant will tie into the existing 230-kv transmission, and additional outlets will be constructed. One of these will be a double-circuit 230-kv line to Moraga substation, providing a second power source over a different route to this important power supply center.

Two large hydroelectric plants with 178,000-kw total capacity are under construction on the Feather River. Transmission outlet for these plants (Cresta and Rock Creek) will make use of the existing Bucks Creek–Bellota circuit and of a second circuit to be strung on the vacant tower position from Bellota to Oroville. A new single-circuit line will be built from this point on through the mountains to Cresta and Rock Creek.

Incoming power from these Feather River circuits and from the Mokelumne River line will find outlet over the existing lines out of Bellota substation, southward along the east side of the San Joaquin Valley, and westward to the Tesla and Newark substations in the San Francisco Bay region. In addition, a further outlet will be provided by a 120,000-kva 230/115-kv autotransformer bank soon to be installed at Bellota, with short 115-kv ties connecting to existing lines in the area. Other new lines are included in the program, but are not specifically described because final plans have not been completed.

When these major additions have been completed, the 230-kv system will extend to all principal load areas and interconnect with all large steam and hydroelectric sources. This is shown schematically in Figure 3.

The postwar transmission construction program of the Pacific Gas and Electric Company completes expansion of the high-voltage system from its earlier beginnings with isolated 230-kv lines, to a completely integrated network that will serve efficiently the rapidly growing electric power needs of northern and central California.

Still further extensions of the transmission system are planned to meet requirements after 1951. As it now appears, because of the economy of double-circuit construction and the gradually decreasing average transmission distance, higher voltages will not prove as economical as 230 kv for this area. Therefore, the period beyond 1951 will see continued expansion at this voltage. However, the transmission planning engineer must be continually alert to the important developmental work at voltages above 230 kv, for in the long-range picture, present concepts well may be revised.

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An Automatic Test Board for Small Motors

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MEMBER AIEE

Performance testing of small motors can be done on this recently designed test board with greater accuracy. This article describes the development, construction, and operation of this board which requires less effort for testing and provides a greater saving in time.

THE PROBLEM of developing a reliable, efficient, and economical method for testing small mass-produced induction motors has been a difficult one for the motor manufacturer for many years. Present-day economics make it impractical to conduct elaborate time-consuming tests, but since the manufacturer guarantees his product he wants to have the assurance that each motor shipped conforms to the established industry standards.

Quality control of the subassemblies and component parts of a motor is obtained by visual inspection, application of gauges, and other relatively simple tests; but the finished product can be judged only by its performance. Thorough performance testing by the older methods, even at the hands of skilled workmen, requires an excessive amount of time and is subject usually to considerable human error.

This article presents the development, construction, and operation of an automatic test board which successfully has solved the testing problems; it is now in use at the Century Electric Company.

The board occupies a floor space of approximately four by six feet, and is installed in the production line between a run-in table and a quiet room. In the normal course of production all motors leaving the assembly line are put

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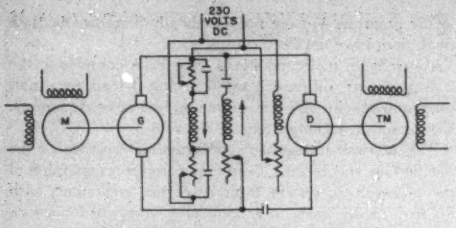

Figure 1. Schematic diagram of connections between motor-generator set and dynamometer showing method used to secure constant current in armature circuit

M = A-c motor of motor-generator set
G = Dual-field d-c generator
D = Dynamometer
TM = Test motor

through a preliminary no-load run-in cycle prior to the performance testing described in this article; those motors which meet the prescribed requirements are then passed to a quiet room where they are checked for noise and vibration.

The test board is designed to handle motors rated from 1/20 to 3/4 horsepower having four, six, or eight poles, in the various types such as polyphase, repulsion-start induction-run, capacitor, and split-phase. Basically, the testing operation consists of mechanically connecting the test motor to a dynamometer and, by means of automatically timed relays, determining such characteristics as:

1. Locked rotor torque.
2. Locked rotor current.
3. Pull-up torque (minimum torque developed by the motor during the period of acceleration from rest to the speed at which breakdown torque occurs).
4. Breakdown torque (maximum torque which motor will develop at rated voltage and frequency without an abrupt drop in speed).
5. No-load current.
6. No-load watts.
7. Check proper operation of governor or relay which disconnects the phase winding from the motor circuit (for single-phase motors only).

From previously conducted laboratory tests on sample motors of the various ratings, definite limiting values are established for all of the foregoing characteristics; it is the function of the test board to reject automatically all motors which do not conform with these limits.

The dynamometer built into the automatic test board differs in a number of respects from the conventional-type dynamometer. The latter usually is suspended on trunion bearings in such a manner that the frame is free to rotate through a few degrees around the axis of its armature shaft. By varying the field excitation or the resistance connected across the dynamometer armature, the tester can produce a state of equilibrium between the dynamometer torque and the torque resulting from weights suspended from a balance arm attached to the dynamometer frame. When this balance point is reached, the torque produced by the weights is recorded but the value of armature current is omitted. Obviously, an equally satisfactory procedure would be to maintain a constant excitation on the dynamometer field and determine the exact relation existing between torque and armature current for that value of excitation. This eliminates the necessity of having a rotatable frame, a balance arm, and balance weights or spring scales; the only requirements being an ammeter in the armature circuit to measure the current so that it may be converted into units of torque.

This is the basic idea of the dynamometer used on the automatic board. The frame is of standard construction and is fastened securely to a nonrotating base which is adjustable to accommodate test motors having different shaft heights. There is no balance arm attached to the frame. The field is separately excited from a d-c shop line and is designed for high magnetic saturation. This maintains practically constant field strength by eliminating appreciable variations in field flux caused by line fluctuations. An ammeter is included in the armature circuit to indicate the amount of current flowing and, by means of tests previously performed on the dynamometer, is so calibrated that each value of current can be expressed in terms of torque.

In operating the test board, the operator first transfers the motor to be tested from the run-in table to a sliding panel on the test board which he pushes forward until the motor shaft engages the flexible coupling which is permanently mounted on the dynamometer shaft. He next attaches clip-leads to the motor terminals and the motor is ready for the automatic test. The operator then presses a starting button which, in turn, energizes a timing cam mechanism.

For the first step in the sequence of operations the test motor is held rigidly to the movable panel by means of an elec-

Figure 2. Front view of automatic test board

tromagnet. A weighted balance arm then is clamped magnetically to the dynamometer shaft and the unit is ready for the locked rotor test.

The torque against which the test motor must act on the locked rotor test can be furnished by suspending weights from the balance arm clamped to the dynamometer shaft, by leaving the weights off of the arm and causing the dynamometer to develop a known value of motor torque, or by a combination of both methods. The latter is used for reasons which will be explained in later paragraphs; that is, a portion of the torque which the test motor must develop on locked rotor is accounted for by weights suspended from the balance arm, and the remainder by a motor torque developed by the dynamometer.

Motor torque is developed in the dynamometer, as previously described, by exciting the field and passing current through the armature. The armature excitation during the locked rotor test is supplied by an a-c–d-c motor-generator set incorporated into the test board, and the electrical connection between the two armatures is controlled by a relay actuated by the timing cam. When this connection is made, the current which flows in the armature circuit is dependent upon the rheostat setting in the separately excited field of the generator. This rheostat setting is made prior to the start of the test and varies with the locked rotor torque required, and with the division of the required locked rotor torque between the dynamometer and the suspended weights. The dynamometer has been tested previously and is calibrated to indicate the amount of locked rotor torque it will develop as a motor for each ampere passing through its armature with constant excitation on the field. Figure 1 shows the schematic diagram of connections.

Immediately after the balance arm has been clamped to the dynamometer shaft the test motor is energized, after which the dynamometer armature is connected to the generator armature. The locked rotor torque test is now in progress. If the test motor fails to develop an opposing torque equal to or greater than the torque of the dynamometer plus the torque caused by the suspended weights, the balance arm is moved in the direction of the dynamometer torque and contacts a micro-switch. A red light flashes on the test board indicating low locked rotor torque. Whether the automatic testing sequence is allowed to continue on a motor which fails to meet the first, or any subsequent test, is at the discretion of the operator. Normally each motor is given a complete test. Any "failure" lights which flash on during the test remain on until the operator pushes the "start" button again, that is, until the beginning of the test on the next motor.

While the locked rotor test is in progress, a relay controlled shunt in the test motor circuit is opened to allow line current to pass through a contact ammeter. If the locked rotor current is not within values of amperes previously selected by the operator, lights flash on the test board indicating that the current is either too high or too low.

After the locked rotor test is completed, the next operation of the timing cam disengages the balance arm from the dynamometer shaft and starts the test which determines the pull-up torque which is the minimum amount of torque

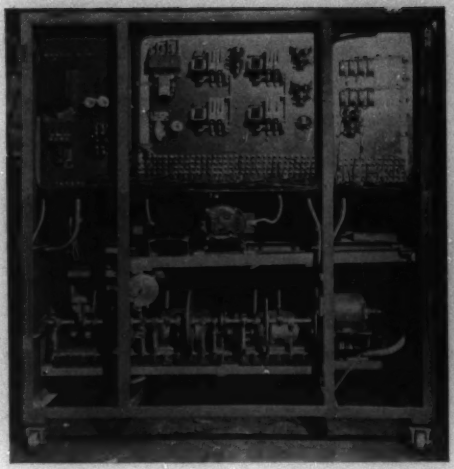

Figure 3. Rear view of automatic test board showing dynamometer and auxiliary equipment

developed as the motor comes up to breakdown speed. Although laboratory tests previously conducted have determined the limiting values of this minimum point for each motor design, the development of a testing method for ascertaining whether all motors conform with these established limits posed an interesting problem.

Obviously, it would be unsatisfactory to follow the conventional method and start the dynamometer from rest with the armature short-circuited through a resistor and the field separately excited; this would result in zero load at zero speed and a load which increased linearly with the speed being twice as great at 1,000 rpm as at 500 rpm. (The words "load" meaning torque load on the test motor, and "current" meaning dynamometer armature current are used synonymously.) Since the dynamometer current builds up linearly with speed this method would afford no indication of whether the motor would develop a given value of torque at all speeds from standstill up to the breakdown speed of the motor.

The problem of obtaining load at zero speed can be solved by passing a current through the dynamometer armature from a separate source. The direction in which the current is passed through the armature at standstill would be the same as the direction assumed by the current generated in the armature when it is revolving. Although under this condition the dynamometer develops a torque at zero speed in opposition to the test motor torque which is the desired result, the fact that it also produces a torque which increases linearly with the speed makes it unsuitable for determining the minimum value of torque between locked rotor and breakdown torque.

It is apparent that a further requirement should provide for maintaining the dynamometer current constant and

independent of the speed of rotation without changing the dynamometer field excitation. There are a number of ways in which this can be accomplished; one of the more obvious methods would be to cause the dynamometer armature excitation voltage to vary inversely with the speed of rotation. This can be accomplished simply and dependably by supplying the generator of the motor-generator set with a field which derives its excitation from the armature circuit voltage but which acts in opposition to the field which establishes that voltage. This simply means that the generator of the motor-generator set is wound with two shunt fields which are in opposition. One of these, which is separately excited, has been described already and was used on the locked rotor test; the other is self-excited. These fields are so proportioned that the separately excited one is relatively weak, and if acting alone would produce a generated voltage approximately 10 or 15 per cent of the rated generator voltage.

So in testing for locked rotor torque, the excitation on the dynamometer armature was preset at a value such that the torque produced was equal to the minimum value of torque permissible in the test motor at any speed between standstill and breakdown speed. The torque produced by the weights on the balance arm when added to the torque produced by the dynamometer resulted in a torque equal to locked rotor torque of the test motor. This value of dynamometer current was established by the operator prior to the test by adjusting a rheostat in the separately excited field of the generator.

When the balance arm is disengaged from the dynamometer shaft at the end of the locked rotor test, the dynamometer armature remains connected to the generator armature. The rotor of the test motor, now free to rotate, starts pulling up to its operating speed. As it does, the dynamometer armature voltage will be increased and the dynamometer now becomes a generator supplying voltage to the armature of the generator of the motor-generator set and its self-excited field. Since this field is in opposition to the separately excited field which established the armature circuit voltage, the generator voltage will be reduced. By suitable generator design a very satisfactory relation is obtained between the increase in voltage caused by the dynamometer speed and the decrease in voltage of the generator caused by the opposing shunt fields, so that a reasonably constant current flows in the dynamometer armature circuit for the pull-up torque test.

If the motor succeeds in pulling up to the speed at which the governor operates, the phase winding will be disconnected from the motor circuit and there will be an abrupt drop in the motor line current. This drop in line current will cause the indicator of a contact meter to move away from a set position. Failure of the contact meter to open will flash a light indicating that the governor did not operate. Another feature of the test board is an electric tachometer which is driven from the dynamometer shaft through a chain drive and which is employed to determine whether the governor operates within the established limits of speed.

Maximum and minimum settings on the contact meter in the tachometer circuit are used in conjunction with the drop in line current to determine if the governor operation occurs within the proper speed range.

The next operation of the timing cam causes a relay to short-circuit the rheostat in the separately excited field of the generator at the same time that another relay inserts a second rheostat into this same field circuit. The motor is then on the breakdown test, the second rheostat having been adjusted prior to the test to permit the proper amount of current to flow through the dynamometer armature to develop the minimum acceptable value of breakdown torque. If the speed of the motor drops below the value set on the contact meter in the tachometer circuit, a light on the test board will indicate failure of the motor to develop the required maximum or breakdown torque and at a speed which is above a minimum permissible speed.

In the next sequence, the circuit to the test motor is opened by a relay. Since breakdown torque still is required to rotate the dynamometer armature, its speed drops almost immediately to zero, and at this instant the generator and dynamometer armatures are disconnected. The test motor (still magnetically clamped to the sliding panel on the test board) is uncoupled from the dynamometer by a cam actuated by the timing mechanism and then is reconnected to the line. At this time the motor is tested for no-load current and watts. If either of these reaches a preselected value, the indicator of a contact meter will close a circuit for the proper warning light, indicating excessive current or watts.

The final operation in the sequence is the high-potential dielectric test. For this test the clip-leads attached to the motor terminals serve as one side of the line, the other side being attached to copper strips in the sliding panel on which the motor rests. At the start of this test a warning light flashes on to show the operator that the dielectric test is in progress. If the motor is grounded, the high-voltage circuit is broken, and a light indicating a grounded motor will appear on the test board.

With the completion of the insulation test, the timing mechanism comes to a stop. The operator detaches the test-board clip-leads and, if the motor is equipped with an overload protector, the motor is connected to a circuit adjoining the test board where it undergoes a protector test. From this station the motor moves on to the quiet room.

The automatic test board provides a positive test on each motor while at the same time relieving the tester of the necessity of reading meters and scales, making decisions, and often repeating parts of the test procedure to clear up points of doubt or to correct for errors in testing. The uniform amount of time consumed by each motor has increased greatly the production of each tester. By the conventional testing methods previously used an average tester could turn out up to 150 motors during an 8-hour shift. The same man using the automatic test board now can turn out from 300 to 500 motors of various ratings in eight hours with considerably less effort than was required by the older methods.

The cost of developing and building the first test board was approximately $10,000, but subsequent boards have been built at a somewhat reduced figure. In view of the highly satisfactory results obtained such an amount spent can be considered a very profitable investment.

Registered Professional Engineers

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REGISTERED professional engineers are engineers granted by one or more states the rights and privileges of practicing professional engineering. The grants are made according to the provisions of state laws known as Professional Engineers Acts or Laws. In many states these laws are designed to safeguard life, property, and public welfare by limiting the practice of professional engineering only to those who are registered professional engineers.

BOARDS OF REGISTRATION

Each state has a Board of Registration for Professional Engineers or a Board of Engineering Examiners which holds meetings, determines applicants' qualifications (sometimes by examination), and issues registration certificates to those who have the education and experience necessary to meet the requirements for professional engineers. These registration certificates (renewable annually for a small fee) are proof that the holders thereof may represent themselves as professional engineering practitioners within the fields for which they are registered.

Those certificates are highly prized hall-marks that not only certify the registrants, but also inform the public that the holder has the education, experience, and skill necessary to qualify as a professional engineer. Nonregistered engineers are restricted in the practice of engineering in many states; they can work only as assistants to or in groups under the direction of registered professional engineers, and, in addition, they cannot approve engineering works or designate themselves as professional engineers without holding a certificate.

Written primarily for the Student membership and the younger members, this article presents a picture of registration as it affects the engineer today, as well as how it is likely to affect him in the future. It reviews the requirements necessary for registration as an engineer and indicates some of the procedures involved in attaining such certification.

Every one of the United States of America, practically all of the Provinces of Canada, the Territories of Alaska, Hawaii, Puerto Rico, and some other governmental entities have professional engineering registration laws; hence, all engineers expecting to practice professional engineering should learn the laws of the states in which they expect to practice.

REGISTRATION LAWS

The laws are not the same in all states nor is it common practice for the states to exercise reciprocal registration. There is, however, a trend toward law uniformity which no doubt in due time will bring increasing similarity for all the states. A "Model Law" was approved and endorsed in 1946 by the following:

American Institute of Electrical Engineers
American Society of Civil Engineers
American Society of Mechanical Engineers
American Association of Engineers
American Institute of Consulting Engineers
National Society of Professional Engineers
National Council of State Boards of Engineering Examiners
American Society of Heating and Ventilating Engineers
American Institute of Mining and Metallurgical Engineers
Illuminating Engineering Society
Society of Naval Architects and Marine Engineers
American Institute of Chemical Engineers
American Society for Engineering Education (formerly Society for the Promotion of Engineering Education)

While not widely adopted, it serves as an excellent guide for bringing the laws of various states toward a common form.

REQUIREMENTS FOR REGISTRATION

The basic requirements for registration are evidence of good moral character, a proper engineering education, and the required engineering experience.

The manner in which these qualifications are determined is published by each state as a part of its legal code. A list of the qualifications, with an application form for registration and instructions regarding its use, may be obtained by applying to the Boards of Registration, the addresses of which appear at the end of this article.

Engineers interested in registration will learn that in order to qualify they must have, in general, from two to four years of professional engineering experience in addition to the four years which are obtained by college graduation at the completion of an accredited engineering curriculum.

They will learn that registration applicants must supply the names of registered engineers who know their work and general community reputation; also that in some cases they must pass a qualifying examination to show that they have sufficient knowledge of mathematics and science, and the necessary practical engineering experience to satisfy the Boards of Registration that they are qualified to practice professional engineering.

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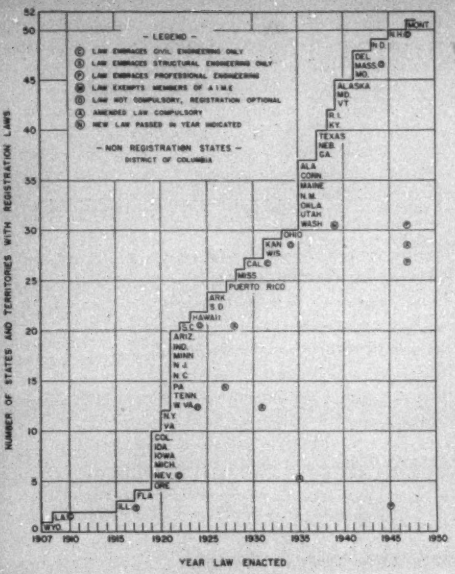

Figure 1. Chart of progressive history of engineer registration in the United States

ENGINEERS-IN-TRAINING

In some states that part of the examination which tests a man's education in mathematics and science may be taken after college graduation and before the applicant has completed the required years of engineering practice. In the states where such provision is made, those who pass that part of the examination are certified as engineers-in-training, a classification which they may carry until they have had the required amount of practical experience at which time they may take the part of the examination designed to prove the applicant's experience qualification.

At this point readers no doubt are ready to ask why engineers who wish to practice professional engineering should be required to spend so much time and effort and some money to become registered. There are several reasons but the prime one is that the majority of engineers after years of observation and study have become convinced that professional registration is a tangible means whereby the public can be informed of engineers who are qualified to assume professional engineering responsibilities. Another is that in this age of large buildings, high speeds, and high-power networks, only the best in engineering can safeguard life, property, and public welfare. Engineering must not be done by psuedo-engineers who either unknowingly or intentionally do not distinguish between professional engineering, subengineering, or craftsmanship, and the work of contractors; nor should engineering be done by those who fail to distinguish between the ability to read and follow plans and the engineering that must be done in preparing plans and specifications. Another reason is that the registration of professional engineers has done much toward informing the public that professional engineering is on a par with other professions, such as law and medicine, and should be so recognized since only well qualified and trained engineers can be registered.

DEVELOPMENT OF THE LAWS

Engineers have reached the registration stage in their usual conservative way of doing things; not by promoting any sudden universal adoption of a nationwide registration plan, but rather by a slow step-by-step method evolved from beginning with a single state. Having found the practice good, the engineers of each of those states that were leaders in having registration laws passed are vying with each other for the honor of having their state declared first in passing a registration law. The holder of that honor seems unquestionably to be Wyoming, which in 1907, went about making registration compulsory for professional engineers and surveyors. The motivation for that action was the need for improvement in the maps being made for water users. Since that law like many a subsequent one included both professional engineers and surveyors, California claims an inferential priority by virtue of having required the licensing of surveyors well back in the preceding century. The California surveyors licensing law stemmed from a need for accurate water rights maps. Strangely enough, California passed its first engineers' registration law, a Civil Engineers Act, in 1929 and then waited until 1947 to expand the act to include chemical, electrical, mechanical, and petroleum engineers. The Wyoming actions of 1907, the Montana Civil Engineers Registration Act of 1947, and the California amendment of 1947 including other engineers in its act mark the time span required for engineers to have all the states pass professional engineers registration laws.

A comparison of this span of activity with that of the physicians and lawyers whom engineers long have desired to match in the matter of professional recognition brings out the fact that in some states physicians have been registered for almost a century. Written examinations for them to qualify, date back to the latter part of the preceding century. Bar examinations began as oral quizzes by superior courts during the last half of the last century and were superseded by written examinations during the first quarter of the present century; thus, it appears that the development of professional engineering, considering the differences in the three professions in their manner of contact with the public, kept reasonable pace with the progress of registration in other professions.

Indeed, it well may be said that registration for engineers reached a state of general practice as soon as it became the natural and logical thing to be done. There are some engineers of mature experience as well as recent graduates who still question the need and/or the desirability of registration. It must be remembered, however, that there are now more than 160,000 registered engineers in the United States. The number is rapidly increasing and is sufficiently great to cause the public to question the

standing of engineers who are not registered. Furthermore, there have been court rulings declaring that non-registered engineers have no legal standing as professional engineers and therefore cannot collect fees for work as such. It has been indicated that professional engineers must have a proper education. This can be obtained most advantageously by graduation from an engineering college with the completion of a curriculum approved by the Engineers Council for Professional Development. The Council publishes annually a list of the approved curricula, copies of which may be obtained from the Council or by application to any one of the professional engineering societies. Every high school and college student, particularly if interested in science and engineering, should be made acquainted with the work of this council by having his attention called to its reports.

ODYSSEY

Professional engineering is a long journey, but for those qualified for the life, a happy one. After college graduation, engineers should plan for a training period where they can acquire practical experience under the direction of registered engineers. After engineers-in-training have completed their training period and obtained registration they must show by their works that they are keeping pace with the profession and are entitled to annual registration renewal. The education of professional engineers can be completed only by retirement or death. The beginning parameter of a professional engineer's education is less definite, for while registration gives public acclaim that engineers are legally qualified as professional engineers, it is evident that professional engineering is a life of growth and evolution rather than a state suddenly acquired by certification. Thus, it is not unreasonable to assume that men begin being professional engineers when they declare their intentions of becoming engineers and enroll as pre-engineering students. From that moment their conduct and aims should be such as to bring credit to the profession.

Professional engineers, to be successful, like successful men in other professions must love their profession above all other forms of business activity and be endowed by these God-given talents: an ambition for hard work, a mind that thinks in the languages of mathematics and science, and a desire to serve their fellowmen.

A brief statement concerning professional engineering such as this cannot be complete; hence, the younger engineers in particular should become acquainted with not only the technical phases of engineering, but they should learn also of the many other factors essential to being professional engineers. A general summary of these other things in their simplest form is presented in the recent annual reports of the Engineers Council for Professional Development where among other items the following sections may be found: A Report of the Committee on Student Selection and Guidance, a Report of the Committee on Engineering Schools, a Report of the Committee on Professional Training, a Report of the Committee on Professional Recognition, a Report of the Committee on Principles of Engineering Ethics, Canons of Ethics for Engineers, Reports of the Boards of Engineering Examiners. These and all the other information contained in the Annual Report of the Council will be found of great value to all persons interested in engineering.

Another organization established to maintain professional engineering on a high plane is the National Council of State Boards of Engineering Examiners. Persons desiring further information concerning professional registration may obtain it by writing letters to the secretary of this Council, the societies listed in this article, or to any of the Boards of Registration or Boards of Engineering Examiners.

National Council of State Boards of Engineering Examiners may be addressed as follows:

T. Keith Legaré, Executive Secretary
505 Carolina Life Building
Post Office Drawer 1404
Columbia, S. C.

Boards of Registration or Boards of Engineering Examiners are

Alabama: Clifton C. Cobb, Executive Secretary
702 Washington Avenue, Montgomery 5

Alaska: Linn A. Forrest, Secretary
Box 995, Juneau

Arizona: Office of Board
Post Office Box 1029, Phoenix

Arkansas: V. E. Scott, Secretary-Treasurer
Post Office Box 175, Pulaska Heights Station, Little Rock

California: Pecos H. Calahan, Executive Secretary
529 Business and Professions Building, Sacramento 14

Colorado: W. T. Blight, Assistant Secretary
20 Capitol Building, Denver

Connecticut: William K. Simpson, Secretary
30 Oak Street, Hartford 6

Delaware: Office of Board
Post Office Box 1266, Wilmington

Florida: Joseph Weil, Secretary-Treasurer
702 John F. Seagle Building, Gainesville

Georgia: R. C. Coleman, Joint Secretary
111 State Capitol, Atlanta

Hawaii: William C. Furer, Assistant Secretary
1909 Aleo Place, Honolulu 54

Idaho: Raymond J. Briggs, Secretary
Briggs Engineer Building, Boise

Illinois: Titus G. LeClair, Secretary
Care of Commonwealth Edison Company, 72 West Adams Street, Chicago

Indiana: L. T. Gootee, Executive Secretary
330 State Capitol, Indianapolis

Iowa: Henry Wichman, Secretary
State House, Des Moines 19

Kansas: H. E. Bullock, Assistant to Secretary
Suite 7, Majestic Building, Topeka

Kentucky: C. S. Crouse, Secretary-Treasurer
University of Kentucky, Lexington

Louisiana: F. W. Macdonald, Assistant Secretary
Civil Engineering Building, Tulane University, New Orleans 15

Maine: Bryant L. Hopkins, Secretary
Bangs Station, Waterville

Maryland: J. W. Gore, Secretary
1101 Key Highway, Baltimore 30

Massachusetts: Albert Haertlein, Secretary
Room 413, State House, Boston

Michigan: Henry G. Grochn, Executive Secretary
705 Cadillac Square Building, Detroit 6

Minnesota: Miss Helen D. Carlson, Executive Secretary
316 New York Building, St. Paul

Mississippi: O. B. Curtis, Sr., Secretary
Post Office Box 3, Jackson

Missouri: Mrs. Clemmie V. Wall, Secretary
Box 184, Jefferson City

Montana: Elson R. Dodge, Secretary
Montana State College, Bozeman

Nebraska: Roy M. Green, Secretary
204 M. A. Building, University of Nebraska, Lincoln 8

Nevada: Stanley G. Palmer, Secretary
University of Nevada, Reno

New Hampshire: Ned Spaulding, Secretary
6 School Street, Hudson

New Jersey: Thomas E. Heathcote, Secretary and Vice-President
921 Bergen Avenue, Jersey City 6

New Mexico: John H. Bliss, Secretary
Post Office Box 1079, Santa Fe

New York: Newell L. Freeman, Secretary
822 Lakewood Avenue, Schenectady 8

North Carolina: C. L. Mann, Secretary
Room 207, Civil Engineering Building, North Carolina State College, Raleigh

North Dakota: Frank E. Cage, Acting Secretary and Chairman
Capitol Building, Bismarck

Ohio: Robert N. Waid, Secretary
21 West Broad Street, Columbus

Oklahoma: Gwynne B. Hill, Secretary
516 Petroleum Building, Oklahoma City

Oregon: E. A. Buckhorn, Secretary
433 Builders Exchange Building, Portland

Pennsylvania: Miss Rebecca J. Nickles, Secretary
324 Education Building, Harrisburg

Puerto Rico: Luis Cueto Coll, Secretary
Post Office Box 3717, Santurce

Rhode Island: Philip S. Mancini, Secretary
242 State Office Building, Providence

South Carolina: T. Keith Legaré, Secretary
Post Office Drawer 1404, Columbia

South Dakota: E. D. Dake, Secretary
School of Mines and Technology, Rapid City

Tennessee: Donald W. Southgate, Secretary-Treasurer
621 Nashville Trust Building, Nashville 3

Texas: Carl L. Svensen, Secretary
912 Tribune Building, Austin

Utah: Mrs. Rena B. Loomis, Secretary
324 State Capitol Building, Salt Lake City 1

Vermont: Walter D. Emerson, Secretary
Norwich University, Northfield

Virginia: Mrs. L. R. Massie, Secretary
4030 Fort Avenue, Lynchburg

Washington: Edward C. Dohm, Executive Secretary
Transportation Building, Olympia

West Virginia: Junius T. Moore, Secretary
215 Morrison Building, Charleston

Wisconsin: Mrs. Josephine V. Hughes, Acting Secretary
State Capitol, Madison 2

Wyoming: Miss Wilma Hageman, Assistant Secretary
201 State Capitol Building, Cheyenne

Color Television Used in Testing Supersonic Engine

To enable its engineers to get a "close-up view" of the roaring, white hot combustion within a ram jet engine, Wright Aeronautical Corporation, the engine-building division of Curtiss-Wright Corporation, has tried out full-color television during a test of a supersonic engine at its experimental laboratories in Wood-Ridge, N. J. The demonstration, which was conducted with the approval of the United States Air Force, is believed to mark the first time that color television has been used to observe this type of engine in action. Wright has been investigating the use of television for tests because it enables engineers to watch engine operation closely without exposing themselves to the intense heat and noise, and the possible physical danger, which are always present in the cell during high output.

The television aspect of the test was under the direction of Dr. Peter Goldmark, director of the Engineering Research and Development Laboratory of Columbia Broadcasting System. The equipment consists principally of a camera, a monitor console, and the equivalent of a 12-inch viewing screen, on which the image is seen in the full sharp colors of a colored motion picture. The camera is placed near the engine to be tested and is connected by a long cable with the screen, which is located in an adjoining room. The picture is not broadcast, and therefore cannot be picked up by any other set. Unlike broadcast television, no sound equipment was used.

The television equipment used was loaned by the owners, Smith, Kline and French Laboratories, pharmaceutical manufacturers who were recently responsible for bringing color television to the attention of the public as a teaching aid in surgery and medicine. Over 30,000 persons watched surgical operations by means of their color televison equipment at a recent meeting of the American Medical Association held in Atlantic City.

Since accurate observation of the colors in flame is highly important in judging engine performance, this color observation system should prove valuable.

The Amplistat—A Magnetic Amplifier

R. E. MORGAN
ASSOCIATE AIEE

Amplifications of 10 to the 12th power have been obtained in one stage of the amplistat in the laboratories of the General Electric Company. This amplifier also has advantages of long life, no starting delay, no moving parts, and is very sturdy and quiet in operation. A description of the operation of the amplistat, diagrams of the circuits, and its advantages and limitations are given in this article.

THE AMPLISTAT is a magnetic amplifier using one or more saturable core reactors in such a way as to secure exceptionally high gain. This is done by having the signal flux operate on the steepest part of the magnetization curve. The basic principles of the saturable core reactor amplifier have been known for a long time and have been thoroughly documented by E. F. W. Alexanderson, Uno Lamm, A. S. Fitzgerald, F. G. Logan, E. L. Harder, L. R. Wrathall, A. Boyajian, C. G. Suits, M. A. Edwards, and many others. By special circuit arrangements developed in the General Engineering and Consulting Laboratory of the General Electric Company, however, it has been possible to obtain performance characteristics superior for certain purposes to those previously obtained.

PURPOSE

The amplistat has solved many problems that could not be solved any other way with a static device requiring little or no maintenance. These applications consist of amplifying signals used in control units such as voltage and frequency regulators; temperature controls; and motor, torque, and speed controls. The amplistat is used also in applications such as audio amplifiers, servo amplifiers, instrument amplifiers, and carrier-current signal amplifiers. In general, the uses are similar to those of thyratrons, amplidynes, and some vacuum tubes. The most common types of signals amplified are direct current or alternating current, but combination signals consisting of d-c components and alternating current or ripple of the audio-frequency range can be amplified.

THE BASIC OPERATION

A typical circuit, coil, and core arrangement used in the work is shown in Figure 1. Although many circuits were used, the basic operation was the same for all.

To simplify the description of the operation, assume a magnetization curve of two almost straight lines and neglect the hysteresis loop. The rectifiers are assumed to be perfect. Then, with no signal on the control windings there will be no flux at the time the voltage rises to zero. (See Figure 2.) The flux then will rise as in a transient operation until saturation is reached. During the time the flux is rising, over 99 per cent of the voltage will occur across the a-c winding, and the current in the load will be less than one per cent of maximum because of the high permeability of the core. Due to the sharp knee of the magnetization curve, the core goes from maximum permeability to the permeability of air in approximately five electrical degrees of the power supply cycle when operating at optimum voltage.

After saturation, the maximum current delivered is limited only by the air core inductance of the a-c windings and impedance of the load. Thus, the load current will lag slightly behind the phase of the supply voltage until the supply voltage returns to zero. Then the rectifier will clip the current, and during the next half cycle of voltage, the flux will return to zero. Also during the next half cycle, the opposite side of the reactor will repeat the foregoing operation. Therefore, at the saturating time of each half cycle, the load current rises from negligible value to maximum in approximately five electrical degrees of the power supply cycle and for the rest of the half cycle follows approximately a sine wave.

When a negative signal is placed on the signal winding, as in Figure 2, the flux will start at a lower value and go into saturation at a later time in the power supply cycle. Therefore, the conducting time and the average load current are reduced. This negative signal can be increased until it becomes so negative that the core does not saturate.

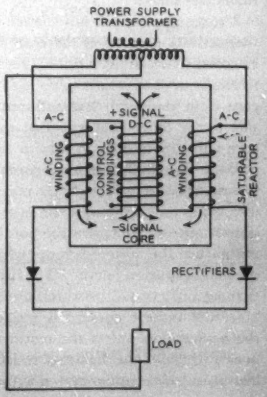

Figure 1. Typical circuit, coil, and core arrangement

Full text of paper **49-183**, "The Fundamental Operation of the Amplistat, a Magnetic Amplifier," recommended by the AIEE Committee on Electronics and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Swampscott, Mass., June 20–24, 1949. Not scheduled for publication in AIEE *Transactions*.

R. E. Morgan is a development engineer of the General Engineering and Consulting Laboratory, General Electric Company, Schenectady, N. Y.

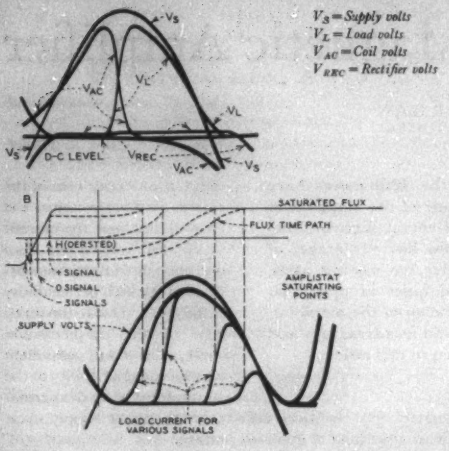

Figure 2a (top). Amplistat waves shapes with saturating point at peak of supply voltage wave

Figure 2b (above). Load current wave shape and phase corresponding to the flux–time path for various signals

The load current then is the exciting current which may be less than one per cent of maximum load current.

When a positive signal is applied, the reverse is true until the signal approaches the knee of the magnetization curve, at which time the output does not increase appreciably with the signal. That is, the output current of the amplistat is controlled by changing the saturating time. This is accomplished by varying the signal current just as the firing time of a thyratron is varied by the control grid voltage. Samples of the characteristics are shown in Figure 3. Figure 3*a* is a typical characteristic of a regular amplistat, while Figure 3*b* is a characteristic of a multistage amplistat with proper interstage phase.

The assumptions do not change the operation because the magnetization curve of the core material normally used is essentially two straight lines. Hysteresis causes the magnetization curve to return quite high in flux density, but the core is so designed that sufficient flux couples from one side to the other in a way that the conducting side of the core will supply enough flux to the nonconducting side to pull the flux density to approximately the negative knee of the magnetization curve in the nonconducting side. Therefore, all of the core traces the outer hysteresis loop, and the signal controls the saturating point by operating on the rising part of the hysteresis loop, which is the steepest part of the magnetization curve. The rectifiers used are selenium, germanium crystal, or vacuum tube. Of those now available, the inverse current is negligible; it does not affect the assumption unless the rectifiers are used considerably over ratings. The forward resistance only causes power loss as in any rectifier power supply.

CIRCUITS

Either single or multiphase full-wave rectifier circuits will work in the amplistat. A few samples of single-phase circuits are given in Figure 4.

The following is a comparison of the circuits which are illustrated.

Circuit of Figure 4a. Excellent circuit for push-pull applications or applications where a 3-wire system is available. Advantages of this circuit are

1. Has a good common point for grounding power supply and amplistat load.
2. Convenient for push-pull applications.

The disadvantages are

1. Requires a center tap transformer for most applications.
2. Requires extra commutating element for high-inductive load.
3. Wave factor in transformer is worse than other circuits, thus requiring a larger transformer per unit power by a factor of two.

Circuit of Figure 4b. Excellent circuit for the average application. Its advantages are

1. Does not need an extra commutating element for normal inductive loads.
2. Does not require a transformer for many applications and better wave factor in transformer when needed.

It has a disadvantage, however:

1. No common point between power supply and amplistat load.

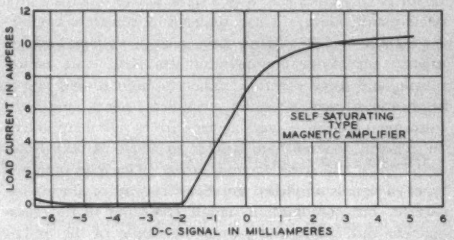

Figure 3a. Normal output-input current curve of the amplistat

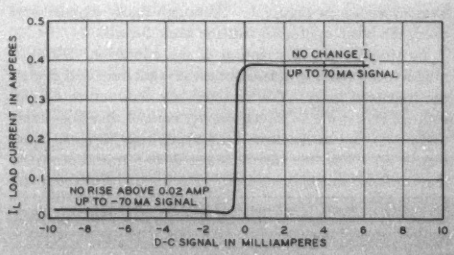
I_L LOAD CURRENT IN AMPERES
0.5
0.4
0.3
0.2
0.1
0
NO CHANGE I_L UP TO 70 MA SIGNAL
NO RISE ABOVE 0.02 AMP UP TO -70 MA SIGNAL
-10 -8 -6 -4 -2 0 2 4 6 8 10
D-C SIGNAL IN MILLIAMPERES

Figure 3b. Output-input current curve of a multistage amplistat with proper phase design

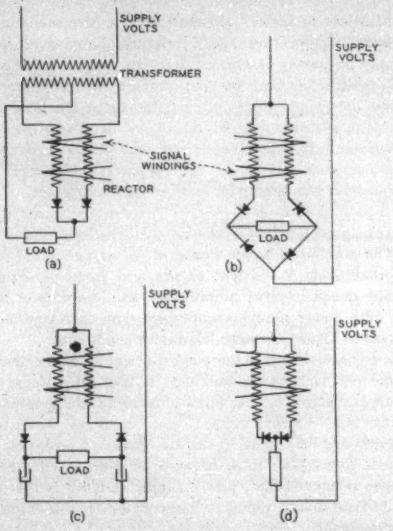

Figure 4. Some typical circuits in single-phase amplistats

Circuit of Figure 4c. This circuit combines a resonance effect between the a-c windings of the saturable core reactor and the filter capacitors to obtain more gain. The advantages are as follows:

1. Has many times the power gain per stage of the other circuits shown.
2. Does not require an extra commutating element or transformer for many applications.
3. Sensitive to smaller signals.

The disadvantages are

1. Sensitive to voltage and frequency.
2. No common point between power and load.
3. Requires capacitors.

Circuit of Figure 4d. The output of this circuit may be rectified if direct current is desired. The slow speed of response is a serious limitation in many instances. The circuit has the following advantages:

1. A-c output.
2. Requires fewer rectifiers.

It has the following disadvantage:

1. Slow speed of response.

THE EFFECT OF SUPPLY VOLTAGE AND FREQUENCY

The effect of supply voltage is shown in Figure 5. The 100 per cent voltage point is chosen because it gives the most change in output power with the minimum output less than one per cent of maximum. As noted in Figure 5, the output varies with supply voltage as the output of a triode vacuum tube varies with plate voltage. Frequency changes have inverse effect. That is, a decrease in frequency is similar to an increase in voltage. If the supply voltage is increased too high, the a-c flux becomes of greater amplitude than that of the negative to positive knee of the magnetization curve and, therefore, the saturable core reactor will go into saturation at some time during the power supply cycle regardless of the amplitude of the signal. Consequently, the signal cannot reduce the output to one per cent or less. However, there are applications, such as in the case of a speed regulator, when the amplistat supplies the motor field so that the output does not have to drop as low as one per cent and frequently to no less than 50 per cent.

For applications such as first stage, interstage, or low output as instrument amplifiers, the maximum output per unit size is less important than in power stages because the minimum size amplistat practical is limited by wire size, and so on. Less than the 100 per cent supply voltage curve then may be used. The gain is just as high, and a smaller signal is required to operate over the amplistat limits. However, if the supply voltage used is too low, the a-c flux is not sufficient to push over saturation without the signal getting into the saturated region of the magnetization curve.

EFFECT OF LOAD IMPEDANCE

As in any circuit, there is an impedance that gives the greatest power transfer. In most applications a constant impedance can be used, so an amplistat to match that desired impedance should be chosen. There are applications such as a motor speed control of the type in which the armature voltage is varied to give a wide range of speeds (sometime over 100:1). The impedance of the load, therefore, will vary tremendously. In many similar applications, the amplistat is chosen to match the impedance at the greatest power point and is checked so that the decrease in efficiency does not get out of range as the load varies from optimum impedance. Figures 6 and 7 show the effect of mismatched impedance on the amplistat. Many applications require a load voltage that does not quite fit the optimum load if available supply voltage is used without a transformer. It is then more economical to mismatch slightly than to employ a special transformer.

SPEED OF RESPONSE

The amplistat has a time constant ranging from microseconds to minutes. The magnitude of this time constant varies with supply frequency and gain per stage. Because

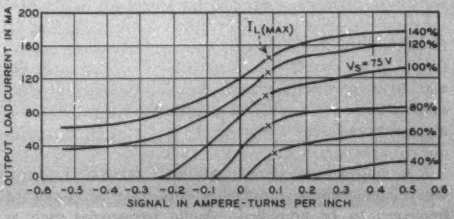

Figure 5. Supply voltage characteristics of the amplistat

Amplistat SR31M, R_L = 300 ohms, B_1 phase

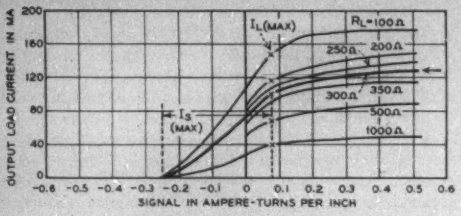

Figure 6. Effect of load resistance R_L on amplistat characteristics

Amplistat SR31M, V_S=75 volts rms, B_1 phase

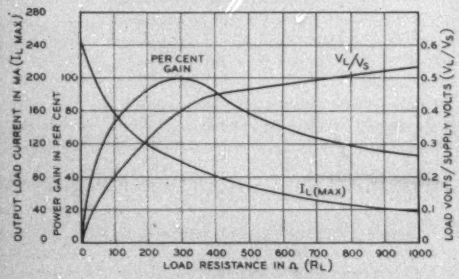
OUTPUT LOAD CURRENT IN MA (I_L MAX.)
POWER GAIN IN PER CENT
LOAD VOLTS/SUPPLY VOLTS (V_L/V_S)
PER CENT GAIN
V_L/V_S
I_L(MAX)
0 100 200 300 400 500 600 700 800 900 1000
LOAD RESISTANCE IN Ω (R_L)

Figure 7. Cross plot of load resistance effects in the amplistat

Amplistat SR31M, B_1 phase

of the relatively high permeability of the saturable core reactors, it is not uncommon to have inductances of greater than 100,000 henries in the control winding. Of the various factors that change the inductance of the signal winding in the saturable core reactor, the number of turns squared is the only thing that is not fixed by the power output design. It has been found that by varying the turns on the control winding, the resistance, and/or feedback; the speed of response can be adjusted from minutes or seconds down to the time of a half cycle of the power supply voltage. (See Figure 9.) Because of the phase control type of a characteristic, the speed of response cannot exceed the time of a half cycle of its power supply voltage. However, by proper design the half-cycle delay can be used as only one delay in a multistage amplifier. That is, motor controls, voltage and speed regulators actually have been made with several stages at a speed of response of one half cycle of the supply frequency. The amplistat can be controlled by frequencies of the same frequency as that of the power supply or greater if they correspond to a harmonic frequency of the power supply. By proper design, a selsyn phase shift can be amplified or a phase shift between two alternators or similar signals can be amplified directly without aid from any other detecting circuit.

If the output of the signal amplified is not to be distorted, then the power supply frequency must be several times the frequency to be amplified. Audio frequencies such as voice or music can be amplified, but the power supply frequency must be ten kilocycles or greater for best results.

Magnetic amplifiers and controls have been made in the General Engineering and Consulting Laboratory for a supply frequency of greater than ten megacycles using a powdered iron core, but the amplification falls greatly when the supply frequency exceeds about ten kilocycles. The amplification was only about five because of the core materials for high frequencies have relatively poor magnetic characteristics for use in the amplistat. However, the application was largely for remote control purposes.

AMPLIFICATION AND SIZE

The amplification per second of an average amplistat is approximately a constant as size and speed of response varies, except in phase amplifiers. Amplifications of 10 to the 12th power have been obtained with one stage in the circuit in Figure 4*c* under laboratory conditions.

It has been found in our work that signals of less than 10 to the −12 watt can be amplified to kilowatt power levels. As in any amplifier, the smaller the signal the greater the effect from supply voltage and frequency variations. Therefore, if very small signals are applied, a push-pull circuit or a stabilizer must be used, or both. With use of proper reactor design, power supply stability is the only limit to still smaller signals. The core used in this amplistat was mumetal.

Figure 9 shows approximate size of the saturable core reactors required to give certain power output. Like a transformer, the size per unit output power varies with the supply frequency. That is, a saturable core reactor which

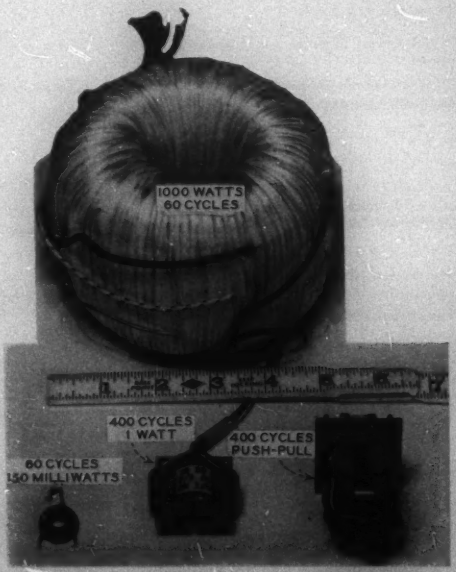

Figure 8. Relative sizes of amplistat reactors

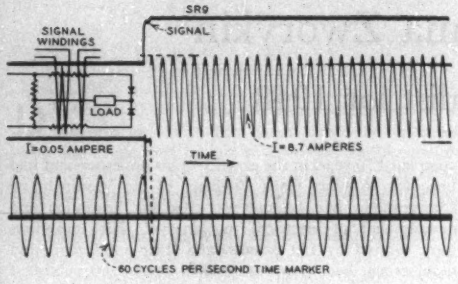

Figure 9. Time constant of a 10-kw amplistat

supplies 200 watts with a 400-cycle power supply is approximately 6.7 times smaller in volume and weight than that which supplies 200 watts with a 60-cycle power supply. This proportionality does not hold true when the power supply frequency approaches higher kilocycles due to the effect of higher frequencies on core materials.

Theoretically, there is no upper size limit for amplistats; however, since the amplistat requires rectifiers, the size of the rectifiers becomes the major space consideration in sizes of ten kilowatts or larger. Therefore, in many applications where alternating current can be used in the output load, the circuit in Figure 4*d* is preferable. A conventional saturable core reactor type also can be used to control large loads. The amplistat can be made to indefinitely large sizes (thousands of kilowatts if necessary).

THE LIMITATIONS OF THE AMPLISTAT

The amplistat is not a "cure-all" for all engineering problems and will not replace all electronic tubes, amplidynes, and so on. The amplistat does not have the available speed of response and high-impedance input of the vacuum tube; and the single ended push-pull circuits for high power are not as efficient as the amplidyne.

These limitations are not serious for most control applications. Time of response of less than 0.01 second seldom is needed in control circuits. This is available with a higher frequency power supply. Input impedance of a large fraction of a megohm is practical.

Push-pull applications involving high-power outputs can be handled, in most cases, with a split load by backing fluxes, and so on. For applications involving approximately 100 watts or less, the amplistat is more efficient than amplidynes.

THE ADVANTAGES OF THE AMPLISTAT

The amplistat has an input winding or windings that are insulated so that any number of signals can be mixed and amplified and still remain completely isolated from the power supply, the output load, and from each other. Also, any high voltage in the signal windings can be insulated from the balance of the circuit.

Experience in this laboratory has demonstrated that the amplistat has long life, no starting delay, no moving parts, and is very sturdy and quite an operation. Similar circuits have operated for over 15 years without replacement of parts. No maintenance or forced shutdowns are caused by the use of amplistats when the components are properly designed. The amplistat goes into operation at the instant the power is turned on, with no delay for parts to come up to speed or filaments to heat. There are no moving parts to wear, no bearings to grease and no noise from rotating parts. The buzz of the laminations is the only source of noise and this can be eliminated by proper damping. The saturable core reactor is similar to a transformer in design, and the other circuit components can be mounted rigidly. The amplistat can be made as sturdy as the mounting components and the life is almost indefinite.

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Measuring Wear in Textiles

Abrasive wear in textiles is determined by a new method developed by the National Bureau of Standards, which measures the change in capacitance of the specimen

Vladimir Kosma Zworykin

Lamme Medalist for 1948

Vladimir Kosma Zworykin (F '45), Vice-President and Technical Consultant, Radio Corporation of America, RCA Laboratories Division, Princeton, N. J., has been honored as Lamme Medalist for 1948 for "his outstanding contribution to the concept and design of electronic apparatus basic to modern television." The Lamme Medal, which has been awarded annually since 1928 by bequest of Benjamin Garver Lamme, was presented to Mr. Zworykin on June 22, 1949, at a general session of the AIEE Summer General Meeting held in Swampscott, Mass., June 20–24.

The Lamme Medal

NELSON S. HIBSHMAN
FELLOW AIEE

TO ADVANCE the theory and practice of electrical engineering and to maintain a high professional standing among its members are the objectives of the AIEE. The preservation of the record of this advance, and the recognition of those who have made outstanding contributions to it, are among the most important of its traditional functions. It is both appropriate and efficient that the means of recognizing current achievement at the same time should honor the memory of pioneers. Such is the case with the two major awards given by the Institute.

The Lamme Medal

The annual award of the Lamme Medal recognizes a member of the Institute, as its donor intended, for "meritorious achievement in the development of electrical apparatus or machinery." At the same time we honor the memory of Benjamin Garver Lamme whose bequest provides the medal and whose career is a continuing source of inspiration to all electrical engineers.

THE DONOR

In selecting the Lamme Medalist for 1948, the Lamme Medal Committee observed a certain timeliness that should be mentioned. It is now within one month of exactly 30 years since Mr. Lamme himself was the central figure in an award ceremony. He had been selected the ninth Edison Medalist of the Institute. At that time he had completed 30 years in the practice of his profession and had been for 16 years Chief Engineer of the Westinghouse Corporation. Mr. Lamme was cited for "invention and development of electrical machinery." His inventions were covered by 150 patents, and their application and development had been described in nearly 100 published technical papers and discussions. His designs and basic methods of design had played a large part in the application of electric power to industry and transportation. This application was the great established achievement on which the electrical industry was growing and thriving when Mr. Lamme was cited for his part.

The work of the 21st Lamme Medalist now is coming in a similar way to its full fruition as part of this generation's outstanding achievement in electrical engineering. The Lamme Medal Committee believes that the memory of a pioneer is most fittingly honored by recognizing in his name the work of those who make in their generation progress comparable to his for his time.

Mr. Lamme's interests were broad. In past years, spokesmen for the Lamme Medal Committee have reviewed his major work in the design of electric machinery; his interest in, and direct contribution to, the selection and training of young engineers; and his hobbies such as archeology, photography, and travel. They have conveyed a clear sense of his shy but warm and friendly personality. I would like to add to the record a word about his relations to the Institute. Except for a period of three years when he was a member of the Board of Managers, he held no major office. Administrative work of any kind was not to his liking. However, several references in his autobiography indicate that he considered a call for participation in the work of the Institute to have a prior claim on his time. He served on several technical committees and made notable contributions, especially in Standards. His 20 major papers and 30 discussions recorded in the *Transactions* show that his participation was active. In 1915 he was selected to represent the AIEE on the United States Naval Consulting Board. He served in this capacity for four years, heading several of the board's most active committees.

The best evidence, however, of the place the Institute held in Mr. Lamme's thought is the fact that he entrusted to it the duty of perpetuating through this award his admonition to "view hopefully the hitherto unattainable."

Full texts of the addresses delivered during the Lamme Medal presentation ceremony at the AIEE Summer General Meeting in Swampscott, Mass., June 20–24, 1949.

Nelson S. Hibshman is Dean, School of Engineering, Pratt Institute, Brooklyn, N. Y., and Chairman of the Lamme Medal Committee.

The Medalist's Career

DAVID SARNOFF
MEMBER AIEE

DR. ZWORYKIN came to the United States from across the seas in 1919. Five years later—the required minimum established by our government—he became an American citizen. He landed in this country with small financial assets, but with exceptional knowledge, energy, and attributes—all of which he placed at the disposal of his adopted land. His great love was television, and he worked tirelessly toward the goal of an all-electronic system that some day would prove to be the world's greatest means of mass communication, education, and entertainment.

ACHIEVEMENTS IN TELEVISION

His first achievement was development of the basic principles of the now famous iconoscope tube. Then he began working on an over-all system incorporating this new electronic "eye." To achieve this he also developed the kinescope, or television picture tube, for the receiver.

With the development of the iconoscope and kinescope, the tide of progress in television definitely turned from a mechanical to the electronic system. On December 29, 1923, Dr. Zworykin filed a patent application on the iconoscope, and in 1924 he disclosed the underlying details of the kinescope. Confident that he was on the right track, he intensified his efforts to develop the complete system, and in 1929 he demonstrated all-electronic television publicly for the first time, proving that it was far superior to the old mechanical system with its motor and revolving disk. Scanning was done electronically and the picture was reproduced electronically.

Vladimir K. Zworykin

Dr. Zworykin continually has made contributions toward improving the science and art of television. His research activities, and the group of scientists working with him in RCA Laboratories, have included many phases of electronics other than television. Their work has led to the development of many interesting and important devices including various forms of secondary emission multipliers and image tubes, prominent among them the Image Orthicon tube as an improved electronic "eye" camera.

David Sarnoff is Chairman of the Board, Radio Corporation of America New York, N. Y.

Their intensive study of electron optics led directly to research in electron microscopy. After several years of concentrated effort, Dr. Zworykin and his associates developed the RCA electron microscope which is capable of magnifications up to 200,000 diameters.

Thus they greatly have extended the range of man's vision, enabling the public to see far beyond the horizon by means of television, while scientists through the electron microscope peer into the submicroscopic world to view hitherto unseen infinitesimal particles.

OTHER WORK IN ELECTRONICS

Dr. Zworykin's research in electronics and electron optics contributed greatly to the victory in World War II. As early as 1934, five years before the war, he formulated plans for an air-borne television system to serve in guiding radio-controlled flying torpedos. Research work on this project progressed steadily and such guided missiles were being employed before V-J Day. With the years of peace ahead, Dr. Zworykin's work on air-borne television, together with the work of RCA and Navy research engineers who succeeded in reducing the size and increasing the sensitivity of the all-important pickup tube, represents a treasure of scientific achievement out of which may emerge a revolutionary extension of television's uses.

It is recorded that during World War II, Dr. Zworykin performed outstanding service as a member of the Scientific Advisory Board to the Commanding General of the United States Army Air Force, the Ordnance Advisory Committee on Guided Missiles, and three important subcommittees of the National Defense Research Committee. In the course of his war work, he directed research resulting in the development of aircraft fire control, television-guided missiles, infrared image tubes for Sniperscopes and Snooperscopes, and storage tubes. He received the Presidential Certificate of Merit in recognition of his distinguished achievements during the war.

INTEREST IN ELECTRONIC COMPUTERS

In January 1947, Dr. Zworykin disclosed work on a universal electronic computer. The principles of the project now are under development at RCA Laboratories with the co-operation of Dr. John Von Neuman of the Institute for Advanced Study at Princeton, N. J. This extraordinary device may open new vistas for all scientists in that it may enable mathematicians to determine new

mathematical processes, which will free them from the older, time-consuming methods.

One interesting and significant use of the computer may be to make possible accurate weather prediction and control. The device permits the rapid computation of the tens of thousands of observations necessary to predict the weather with accuracy. The difficulty heretofore has been that if computations were carried out accurately, years might elapse before arriving at an answer representing the prediction of as little as a half day ahead.

Use of the electronic weather forecaster in weather control contemplates not the bringing about of climatic changes over vast areas, but the modification of local weather disturbances such as the breaking up or deflection of storms, precipitation of moisture in drought areas, the prevention of killing frosts, and the elimination of dangerous fogs. Thus, to quote Dr. Zworykin, "The old saying about the weather, as something that everybody talks about but no one does anything about, has ceased to be justified."

Another of Dr. Zworykin's inventions is farther removed from the dream world. It is a novel electronic clock with no moving parts, motors, wheels, main-spring, or hands, which tells the time down to each second. This ultramodern timepiece has more than 170 electron tubes, but Dr. Zworykin will tell you it is quite simple. It counts the 60-second pulsations of ordinary electric current and indicates that count by means of lights in seconds, minutes, and hours.

Out of another of Dr. Zworykin's ideas involving electronic counters may come the first truly accurate method of polling this country's citizens on matters of national interest. Such a system, when fully developed, would enable the television home receiver to act as a miniature transmitter in sending "yes" or "no" signals to a counting device at the television station. With such a system, the sentiment of the citizenry on important issues could be obtained almost immediately.

THE MEDALIST AS LECTURER AND AUTHOR

As Dr. Zworykin's prominence in television and electronics has risen, he has been called upon to lecture before learned societies all over America and in a number of countries in Europe. He represented the National Academy of Sciences at the Scientific Congress in Liege, Belgium, in 1947, on the occasion of the centennial of the Association of Engineering Graduates of the University of Liege. That same year, he represented the National Academy of Sciences, the Institute of Physics, and the Radio Corporation of America at an international conference of radio engineers in Rome, organized to commemorate the 50th anniversary of Marconi's invention of wireless.

Dr. Zworykin is coauthor of four books in the electronics field: "Photocells and Their Applications," "Television," "Electron Optics and the Electron Microscope," and "Photoelectricity." He also is author and coauthor of many scientific papers on photoelectricity, electron optics, and electron microscopy.

I recently asked Dr. Zworykin what he is presently dreaming about, and he smilingly replied that he never dreams, he sleeps soundly. But he added that in his working-day his mind is very much occupied right now with the great possibilities which he foresees for industrial television.

This, then, is the 1948 Lamme Medalist, Dr. Vladimir Kosma Zworykin, scientist extraordinary of this age.

The Engineer's Role in the Progress of Science

VLADIMIR K. ZWORYKIN
FELLOW AIEE

THE PRESENTATION of the Lamme Medal in recognition of my efforts in the development of television does me a great honor. I appreciate it all the more since some of my earlier efforts in this field, at the Westinghouse Electric Corporation in Pittsburgh, Pa., coincide with the tenure of Mr. Lamme as Chief Engineer of that corporation. In considering the engineer's role in the progress of science, I shall be mindful of the great contributions made by Mr. Lamme and his generation of able engineers.

THE SCIENTIST AND THE ENGINEER

The events of the last war have catapulted science into the forefront of public consciousness. Whether regarded with admiration or distrust, the scientist's importance in the scheme of things is accepted. Never too careful in its distinctions, the public seems to have replaced the businessman and engineer with the scientist as its prophet of the new age—with or without the scientist's consent. This change in fashion need not concern us too much; in some measure it redresses an unbalance in salutary fashion. However, it provides an occasion for a re-examination of the role of the engineer, not merely in advancing the standard of living and adding to our comfort and convenience, but in the progress of science itself.

Actually the man in the street becomes conscious of scientific advances only as the engineer translates them into an instrument, a manufacturing process, or a machine. Consider, as an example, the field of electricity. The basic principles upon which every electric device rests were discovered and enunciated by physicists such as Faraday, Maxwell, Hertz, and Lorentz. Yet, even though Faraday foresaw the practical potentialities of his discoveries sufficiently to counter the contemptuous comment of a member of Parliament with the remark, "You may tax it some day," these men, by themselves, could not have ushered in the electrical age. That took engineers—men whose extensive, rather than intensive, knowledge of many fields enabled them to utilize the findings of physicists, chemists, metallurgists, mechanics, and others for the construction of dynamos and motors, cables, dams, and all the rest of the factors playing a role in the production, distribution, and utilization of electric power and the creation of an electrical communication network.

Commonly the development from scientific discovery to practical utilization is continuous. Under such circum-

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stances the distinct functions of scientist and engineer are readily confused. The strategic importance of the engineer in making the products of scientific discovery available to the public becomes evident when, for prolonged periods, a scientific discovery remains dormant because engineering talent is not applied to its utilization. For example, two or three generations of physics students were delighted by the brilliant colors of gas discharges in Geissler tubes before Claude promoted their use in outdoor signs, giving Main Street its characteristic garish hue. Again, both the copious emission of ultraviolet radiation by the low-pressure mercury arc and the efficient conversion of this radiation into light by various crystalline substances, phosphors, were known long before engineers undertook the development of our present-day fluorescent lamps. The photovoltaic effect in selenium was discovered at least 50 years before; in the 1930's, it became the subject of intensive study by engineers and, soon thereafter, universally employed in exposure meters.

In all these cases the emphasis has been placed on the engineering development succeeding a scientific discovery. At the moment we are more interested in the fact that engineering progress uniformly promotes scientific discovery by giving the scientist tools of increasing effectiveness. The present development of nuclear science appears inconceivable without the assistance received from the electronic industry in the form of high-power oscillator tubes and control equipment of all kinds. The same applies to the study of cosmic rays, the research into the nature of the electron through the study of atomic resonances, and almost every other problem in the forefront of present-day scientific interest.

HISTORY OF TELEVISION

Let us consider the history of television engineering in somewhat greater detail. It seems reasonable to regard the application of electronic methods to television as the crucial step making present-day high-quality television possible. In the same year in which J. J. Thomson identified the electron, Ferdinand Braun invented the cathode-ray oscillograph which became a measuring and testing tool of ever-increasing importance in electrical engineering. At the same time, it contained the three essential elements of all electronic viewing tubes—the electron beam, the deflecting fields, and the fluorescent screen—and was actually applied for this purpose by Boris Rosing, a decade later.

Rosing labored under two handicaps: On the one hand, the problem of amplification as yet was unsolved so that picture signals of adequate strength for beam modulation were unavailable; on the other, the basic principles for forming a small, sharp, and intense electron spot on the fluorescent screen were as yet unknown. As a result, any reproduced picture of necessity would have been very unsharp and faint.

Both of these handicaps were removed in the course of the succeeding two decades, by de Forest's audion and Busch's formulation of electron optics. While de Forest was greatly and even primarily concerned with the practical application of his invention, the discovery of the principles of electron optics was the outcome of a careful analysis of the factors limiting the accuracy of the measurement of the ratio of the charge and mass of the electron—a purely academic problem. However, it soon was applied by engineers to the urgent problems of precision oscillography and of electronic picture pickup and picture reproduction. The same engineers and laboratories that concerned themselves with these problems repaid science generously by supplying it with a new tool of extraordinary power and versatility, the electron microscope. Only the combined knowledge of vacuum technique, electronic control methods, magnetic materials, and so forth, possessed by these engineers was capable of creating an instrument which is both practical in its operation and comes close to achieving the optimum in the resolution of detail as set by the basic properties of electrons and electron lenses.

A second development, which is an outgrowth of efforts to increase the sensitivity of television pickup devices, is the multiplier phototube. In combination with suitable phosphors this tube is quickly achieving a dominant role as detector for radiations and high-speed particles in nuclear and cosmic ray research, unparalleled in sensitivity and speed of reaction. Of comparable importance are its uses in spectroscopy, spectrochemical analysis, astronomy, X-ray measurements, and a host of other fields of science.

TELEVISION AS A MAJOR INDUSTRY

After the effectiveness of the iconoscope and kinescope, the basic electronic pickup and viewing tubes had been demonstrated and the principles on which a successful television system must be founded had become accepted, nearly a decade was needed before television was ready for the public. This period saw many improvements in the pickup tube and viewing systems, improved amplifier and antenna designs, studies in ultrashort-wave propagation, experiments in programming, and field tests. The justification for this ample preparation is to be sought in its results. Since, at the close of the war, television broadcasting was given free rein, it has developed into a major industry. Nearly a million sets were produced last year, increasing the number in the field by a factor of six, while, at the same time, the number of operating stations rose from 18 to nearly 60. A network consisting of concentric cables with ultrahigh-frequency links joins the Eastern Seaboard with the Great Lakes district and may span the continent in the not too distant future. The rate of growth of television broadcasting appears to be hampered only by the limited space available in the frequency spectrum.

There are, however, many applications of television which are not so limited. If the transmission is by cable or along sharply defined radio beams the problem of interference, and hence of frequency allocation, vanishes. As a matter of convenience, it has become customary to refer to television applications satisfying this condition collectively as "industrial television." Even now these uses are important and widespread. Special, compact cameras and receiving units are being built for such purposes as the surveillance of gauges and machines at inaccessible and remote places. Dangerous operations currently can be

watched by the television camera while the operators remain at a safe distance. Systems such as Teleran promise to give the aircraft pilot continuous visual information on his position relative to the terrain and relative to other airplanes, increasing the safety of flight in all kinds of weather. The outreach of important sessions, such as those of the United Nations Assembly, is increased by providing television receivers in separate halls for the press and an overflow audience. Similarly, department store managers can present to customers fashion shows and special sale items through television receivers located at a number of strategic points in the store. In several large new hospitals a threefold use of television is planned: Television is to serve for the entertainment of the patient, for his continuous surveillance by the nursing staff, and, finally, for the observation of operations by visiting physicians, consultants, and medical students.

It is not difficult to visualize uses which a number of these techniques may have in the scientific field. I wish, however, to point out one other by-product of television research which promises to play a vital role in scientific investigation—the storage or memory tube. This tube, by increasing speed of storing and releasing information in electronic computing machines, promises to make possible the rapid solution of problems whose complexity now baffles us. Only through the application of such devices, for instance, does the creation of a truly reliable weather prediction service appear feasible.

I have given a few examples of the contribution of engineering, and television engineering in particular, to the progress of science. However, the greatest benefits can be achieved only through the intimate interplay of fundamental science and engineering. As long as both fields of endeavor are adequately staffed and exchange information freely, we need not fear for the material progress of our civilization.

Proposed Frequency Band Designations

AN AIEE COMMITTEE REPORT

THE CHART of Figure 1 was prepared through the efforts of the AIEE Joint Technical Committee on Standard Frequency Bands and Designations. The primary object of the chart is to promote the use of band designation numbers to indicate frequency ranges over the whole useful range of frequencies which occur in nature, thus giving a single co-ordinated system. It will be noted that the band number is the exponent of ten corresponding to the lowest frequency of the band.

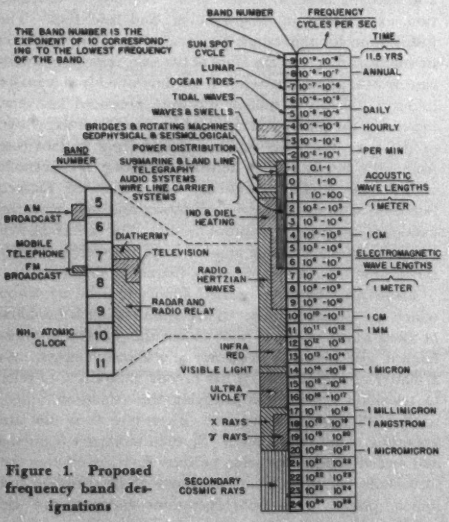


Figure 1. Proposed frequency band designations

The wave length values, both acoustic and electromagnetic, are given simply as reference points and it is not intended that they shall be used as band designations.

The notation opposite band (−1) indicates that frequencies in this range often are of particular interest to bridge designers and to designers of large rotating machines. Similarly, the frequencies of band (0) are of particular values in geophysical prospecting and occur often in seismological phenomena.

The dividing line between various groups may be subject to comment. For instance, television is indicated as covering higher frequencies than the officially assigned bands. However, even higher frequencies than indicated may be used for this purpose some day.

The communication bands are shown at the left to double scale since the notations became too crowded otherwise.

This diagram supplements a brief report and abbreviated table which appeared in *Electrical Engineering*, May 1947, page 471.

Full text of a report prepared by the AIEE Joint Subcommittee on Standard Frequency Bands and Designations.

Personnel of Subcommittee: Thomas Spooner, *Chairman* (representative, Electronic Standards Committee); C. T. Burke (representative, Instruments and Measurements Committee); G. B. Ransom (representative, Communication Committee); F. B. Silsbee (representative, ASA Sectional Committee *C68*); J. E. McCormack (representing ASA Electric Light and Power Group).

Electrolytic Zinc Plant

JOSEPH S. BOWMAN
MEMBER AIEE

THE electrolytic zinc plant of the American Smelting and Refining Company at Corpus Christi, Tex., was designed by company engineers and built during 1941 and 1942 for production of high-grade metallic zinc; the first zinc was produced in October 1942.

The plant is divided into eight divisions: concentrates storage, roasting, acid, leaching, purification, electrolysis, melting and casting, and power. A plan of the plant is shown in Figure 1.

This article presents a detailed description of the electrolytic process used in the production of metallic zinc at the electrolytic zinc plant of the American Smelting and Refining Company at Corpus Christi, Tex. The power division for the entire plant, which represents 35 per cent of the total plant installation cost, also is described.

The zinc ore is brought to the plant in the form of finely ground concentrates containing approximately 57 per cent zinc in the form of zinc sulfide (ZnS), and some impurities. The zinc in the concentrates is roasted to zinc oxide (ZnO) in two flash roasters, a process similar to burning powdered coal in boiler plants. Under normal operations 160 tons per day of concentrates are roasted. Gas from the roasters contains sulfur dioxide (SO_2) from which 125 tons per day of sulfuric acid is made and sold.

The ZnO from the roasters is leached in spent solution from the electrolytic cells, which contains sulfuric acid (H_2SO_4), giving an impure zinc sulfate solution ($ZnSO_4$). This solution is filtered and purified to remove the impurities, some of which, such as gold, silver, copper, and cadmium, are recovered. The purification process is of utmost importance if pure zinc is to be produced, and, therefore, must be done with care. A typical analysis of the purified solution is

Zinc	172 grams per liter
Manganese	5 grams per liter
Iron	15 milligrams per liter
Copper, cadmium, cobalt, and so on	1 milligram per liter or less

The manganese is added during the leaching process as one of the purification reagents and is not deposited out of solution by the electric current with the zinc.

ELECTROLYSIS

The metallic zinc is recovered from the purified zinc sulfate solution ($ZnSO_4$) by the passage of an electric current through the solution in electrolytic cells. Current is led to the cells through lead anodes containing a small quantity of silver. The zinc is deposited onto aluminum cathodes for a period of 24 hours and then stripped off by hand.

The purified solution of zinc sulfate from the purification section flows into wood-stave lead-lined storage tanks at the electrolyzing division. Each of these tanks can store 150,000 gallons. Gravity of the solution is adjusted in these tanks by addition of condensate from heating coils or from the power plant, if needed. From these tanks the solution is pumped by three 1,500 gallons-per-minute pumps into the main cell-feed lead-lined wood launder which extends the length of the cell room. Certain conditioning reagents are added where the solution enters this launder. The solution then flows to 32 launders each of which feeds a bank of ten cells. From these bank launders each cell receives a regulated quantity of solution of approximately eight gallons per minute. A by-pass allows the excess flow in the main launder to be returned to the spent solution storage tanks.

The cell overflow discharges on the far side of the cells from the feed into launders along each row of cells, and these in turn flow into a main return launder. The individual bank launders are made of an insulating plastic to reduce stray currents. The two main return launders are made of wood and are lead-lined. These discharge into two lead-lined wood-stave hot spent solution storage tanks. Each has a capacity of 55,000 gallons. From these tanks some of the hot solution is pumped by two 900 gallon-per-minute pumps to the leaching division through a lead pipe. Three 1,500-gallon-per-minute pumps circulate the hot spent solution to a 3-section forced-air draft cooling tower from where it flows back to the cool solution storage tanks for recirculation through the cells.

The total volume of solution in the cell circuit is about 350,000 gallons. About 40,000 gallons of water per day are evaporated in the cooling tower. This tower is constructed of acidproof brick with lead-lined basins. It was the first cooling tower of its kind built for the purpose of cooling a sulfuric acid solution. Its three fans force a total of 356,000 cubic feet of air per minute through the tower. Each fan is direct driven by a 100-horsepower motor.

The cells are installed in two electric circuits, each of 160 cells, of which 20 are in the nature of spares. This number of cells is taken out of the circuit each day for cleaning. So there are 140 active cells in series across each 500-volt d-c circuit. The cells are arranged in 32

Essential substance of paper 49-124, "Electrolytic Zinc Plant of the American Smelting and Refining Company at Corpus Christi, Tex.," recommended by the AIEE Mining and Metal Industry and the Chemical, Electrochemical, and Electrothermal Committees and approved by the AIEE Technical Program Committee for presentation at the AIEE South West District Meeting, Dallas, Tex., April 19–21, 1949. Not scheduled for publication in AIEE *Transactions*.

Joseph S. Bowman is an electrical engineer in charge of design and installation of the electrical portions of the electrolytic zinc plant, American Smelting and Refining Company, El Paso, Tex.

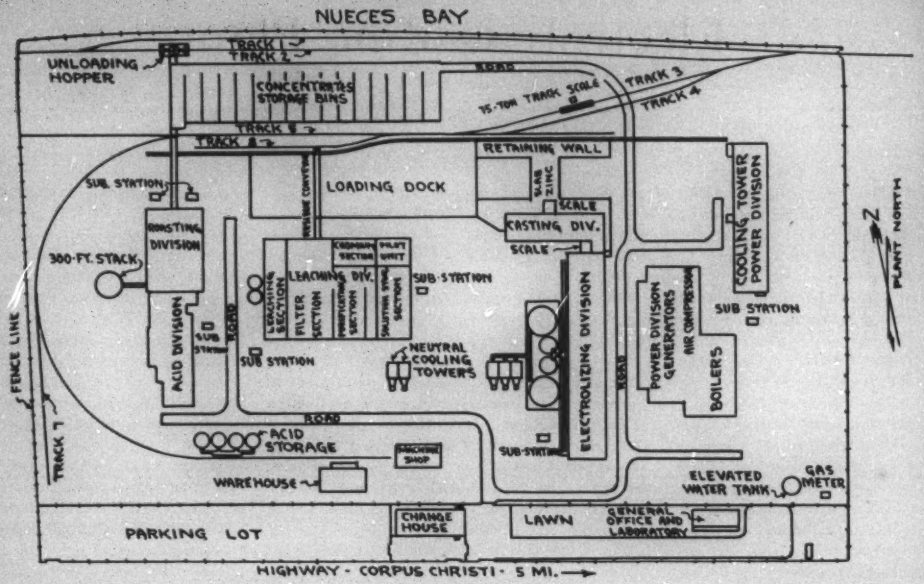


Figure 1. Plan of electrolytic zinc plant at Corpus Christi, Tex., showing the location of the electrolyzing and the power divisions on the right

rows or banks of ten each, or 16 banks in each circuit. Each cell contains 25 anodes and 24 cathodes. The current for one circuit enters the first cell of number 1 bank from a positive copper conductor bar through the 25 anodes in parallel, through the electrolyte to the 24 cathodes in parallel, to the anodes of the next cell and so on through the first bank of ten cells to a copper cathode bar at the rear of bank 1, through a copper connecting bar to the anode bar at the rear of bank 2, through the 10 cells of bank 2 to the cathode bar at the front end of bank 2, to the connecting bar between banks 2 and 3, and so on through the 16 banks. Alternate banks of cells are equipped with removable cutout bars at the front end to provide a ready means to remove the 20 cells in two adjacent banks for cleaning and maintenance.

The cells are made of 4-inch thick reinforced concrete and lined inside with sheet lead. Inside dimensions are 7 feet long by $2\frac{1}{2}$ feet wide by $4\frac{1}{2}$ feet deep. The cells are set on glass blocks to insulate them from ground. The anodes are cast in the plant of silver-lead alloy, in the form of a grid $19\frac{1}{8}$ inches wide, 31 inches long, and 5/16 inch thick. Openings in the grids are 9/16 inches square. The anode head bars, from which the anodes hang in the cells, are made of copper and covered with antimonial lead to which the anodes are attached by burning the anode to the lead covering. When the anodes are removed from the cells for cleaning they are lifted 12 or 13 at a time by means of an anode lifting device and hand-operated chain block supported on a trolley on an *I* beam above each bank of ten cells. In the cells the anodes are spaced three inches apart and porcelain button insulators attached to the anodes near the lower corners aid in maintaining their correct spacing.

The cathodes are made of rolled aluminum sheet, 21 inches wide, 36 inches long, and 3/16 inch thick; and are attached to the aluminum alloy head bars by welding. Lugs on the head bars provide a convenient means for lifting. The lifting device, its chain block and trolley being insulated from the supporting steel by a strain insulator, raises 12 cathodes at a time from the cells and transfers them to the stripping floor. After the zinc is stripped from the 12 cathodes, they are returned to the same cell. Removable wood strips on the two vertical edges prevent the zinc from being deposited there, and thus make stripping easier. They also help to maintain proper cathode spacing in the cells.

A unique feature[1] developed for this plant is the design of contact between cathode head bars in one cell and anode head bars in the next. This is a truncated cone-shaped piece of copper with small end down and a threaded stud on top screwed into a tapped hole in the underside of one end of the cathode head bar. The cone wedges vertically between milled copper buttons attached to the end of anode head bars in the next cell. The cone-shaped contacts on the cathode and anode head bars also form a wedge-type contact with the conductor bars at the two ends of the cell banks. This special type of contract provides for easy and effective cleaning.

Anodes and cathodes are supported on specially shaped porcelain insulators set on top edges of the cells. Head bars of electrodes set in grooves in the insulators which are spaced to give the correct spacing between anodes and cathodes.

When removing the 12 cathodes from the cell for stripping, every other one is removed at one time. By leaving half the cathodes in the cell the electric circuit is not broken. The cathodes are transferred to stripping racks designed so that both sides of the cathodes are easily accessible. The 24-hour deposit of zinc is manually removed from the cathodes by the use of a stripping knife and mallet. The zinc sheets are stacked in racks from where they are picked up by a gasoline-electric truck equipped for the purpose with lifting forks. The zinc is taken to a scale, weighed, and deposited on the charging platform at the melting furnace.

Anodes and cells are cleaned every 16 days. The anodes are scraped, brushed, and repaired when necessary, before being replaced in the cells. A vacuum cleaning system is used for removal of solution and manganese slime from the cells. Any solids which the vacuum system cannot remove is scraped off and removed manually.

A froth on the surface of the cells, produced by frothing reagents, minimizes the mist which otherwise would rise from the cells along with the escape of gas bubbles produced during electrolysis.

Current density in the cells is between 50 and 60 amperes per square foot. This current flowing through the resistance of the electrolyte generates a large amount of heat (some 10,600,000 Btu per hour) which is removed by the continuous flow of solution through the cells and by circulating the hot spent solution over the cooling towers described in a preceding paragraph. Temperature of the solution in the cells is maintained at approximately 97 degrees Fahrenheit.

The percentage of zinc and the strength of sulfuric acid in the electrolyte in the cells is maintained as nearly constant as possible at 60 grams per liter of Zn and 180 grams per liter of H_2SO_4. A typical analysis of the solution leaving the cells shows the zinc content to be 56 grams per liter and the sulfuric acid to be 200 grams per liter.

It is interesting to note the great number of individual items in the cell operation. Remember, there are 320 cells, each equipped with 25 anodes and 24 cathodes; that means a total of 8,000 anodes and 7,680 cathodes in use. Since 40 cells are out of service there are two sheets to be stripped from each of 6,720 cathodes or 13,440 zinc sheets to be handled every day. Their weight averages 12.25 pounds each, or a total of 164,600 pounds per day, giving a monthly production of 2,500 tons.

Average energy consumption in the electrolytic cells to produce a pound of zinc is approximately 1.5 kilowatt-hours.

The zinc sheets, after being weighed and stacked at the melting furnace platform, are charged into the furnace. This is a reverberatory furnace having a capacity of 140 tons of molten zinc and is fired by natural gas. Fumes and gases from the furnace are cooled by passing through 16 vertical cooling pipes and forced by a 12,000-cubic-foot-per-minute fan through a baghouse where the zinc oxide, inadvertently formed in the melting furnace, is recovered.

Molten zinc is taken from the furnace manually in two 500-pound-capacity ladles supported on trolleys, and poured into molds. There are 80 of these molds. After being filled, the top surface is skimmed and then the full molds are sprayed with water to chill the metal which quickly solidifies, and the bars of zinc are dumped. They weigh 50 pounds each. They are stacked by hand in 4,000-pound stacks, picked up by forked trucks, weighed, and stacked in 50-ton lots on the shipping platform. From here they are loaded into railroad cars. The zinc produced analyzes better than 99.99 per cent pure.

POWER DIVISION

Power for the plant is generated in the company's power station, one of the principal divisions, and representing 35 per cent of the total plant installed cost. Steam is generated in three natural-gas-fired steam generators (boilers), each rated at 125,000 pounds of steam per hour at 425 pounds per square inch (gauge) and 700 degrees Fahrenheit total temperature, and equipped with turbine-driven induced- and forced-draft fans, tubular-type air preheater and water walls. One steam generator is a spare unit since two can supply sufficient steam for continuous full load plant operations. All make-up water for boiler feed is softened in a water treating plant.

Electric power is generated by seven 2,500-kw steam turbine generators. Two of these units have 2,000-kw 2,400-volt 3-phase 60-cycle 3,600-rpm alternators which supply power for all uses except the electrolytic cells. The alternators are each equipped with a closed air cooling system. The two turbines supply some of the process steam from 75-pounds-per-square-inch automatic extraction nozzles, and lower pressure nonautomatically extracted steam for boiler feed water heating. Any remaining steam goes to surface condensers, the condensate going into the boiler feed. The other five turbines are straight condensing, nonextraction type. Each one drives two 1,250-kw 500-volt d-c generators through speed reduction gear units. The turbines operate at 3,600 rpm, and the generators at 750 rpm.

The d-c generators are cooled by air from a common duct below, passing through the generators, and discharging into the turbine room. The air is supplied by a 130,000-cubic-foot-per-minute fan which draws its air through an evaporative-type air filter and cooler having fiber glass elements that are kept wet and clean by water sprays.

Turbine condenser cooling water is cooled in a redwood cooling tower having 11 sections, each equipped with an induced-draft fan on top driven by a 40-horsepower 2-speed motor. Control equipment for the motors is installed in a group in a weatherproof steel housing on the ground near one end of the tower.

The a-c switchgear is typical metalclad type, equipped with electrically operated oil circuit breakers from a storage battery, and automatic frequency control, a refinement seldom found in industrial power plants of this type. Alternator windings are protected by ratio differential relays.

The d-c switchgear is the type usually found in large electric railway power stations. It is equipped with electrically operated generator and feeder air circuit breakers, the positive and negative circuit breakers being operated independently.

Switching is arranged so that the numbers 1 and 2 d-c turbogenerator units supply power to number 1 feeder circuit to the electrolytic cell room, and turbogenerator units numbers 4 and 5 supply power to electrolytic feeder circuit number 2. Number 3 generating unit may be switched to either feeder circuit, or half its capacity (1,250 kw) to each feeder circuit. No provision is made to parallel the two feeder circuits.

The original plan was to use the number 3 d-c generating unit as a spare for the other four, but it soon was found that the zinc plant had sufficient capacity to utilize the output of the five d-c generators and so produce 25 per cent more zinc than was first anticipated. So normal operation is for all five units to operate at practically full capacity, supplying two circuits, each with 11,500 amperes at 500 volts, a total of 11,500 kw.

The 2,400-volt a-c distribution system, consisting of seven feeders, is carried in metal conduit underground, either embedded in concrete or on the outside building walls, so there are no pole lines through the plant. The reason for using metal conduit was that there is a marked earth movement in the area which fibre or tile duct cannot withstand; and the object of embedding the metal conduit in concrete is to protect it from the active corroding effect of the earth resulting from the large quantity of salt.

The ground at the power plant location was soft so it was necessary that both the building and heavy equipment foundations be supported on piles. In the area covered by the power plant there were more than 1,200 wood piles driven an average of over 40 feet into the ground. Over a considerable area under the turbogenerator foundations, the piles are spaced every $3\frac{1}{2}$ feet in both directions. Some of the ground was so wet and soft that interlocked sheet steel piling was driven to retain the earth.

All motors throughout the plant, except a few large 2,200-volt ones in the power station, are 440-volt 3-phase induction or synchronous type. The 2,400-volt primary system feeds eight unit-type substations located near the various departments. These substations consist of a 300- or 450-kva 3-phase 2,400- to 480-volt transformer and a circuit breaker compartment containing two or three air circuit breakers and watt-hour meters each supplying 440 volts to group-operated control centers in the several sections of the plant. The substation in the powerhouse is of the indoor type with an air-cooled transformer. The other seven are outdoor types with oil-insulated transformers and outdoor-type steel enclosures for the circuit breakers and meters.

The control centers contain combination magnetic starters with air circuit breakers for each motor in the group, with control start–stop push buttons at locations convenient to the operators.

The two d-c feeder circuits to the electrolytic cell room are installed in an underground tunnel between the power plant and cell room. Each circuit is made up of a positive and negative conductor each having a cross-sectional area of 18 square inches of copper, made up of 12 $\frac{1}{4}$- by 6-inch bars grouped in the following manner:

III III
III III

and supported on special insulated clamps. This arrangement of bars carries the same amount of current at the same or lower temperature as 25 square inches of copper will carry when the bars are arranged in the conventional way, all at the same elevation and spaced 1/4 inch apart. This design of conductor bars saved more than five thousand dollars in the cost of copper. All surfaces at joints in the conductor bars were silver-plated with a portable brush plating equipment, to prevent hot joints on account of the high resistance caused by oxidation of the copper.

REFERENCE

1. United States Patent, Number 2,443,112.

2. Electrolytic Zinc at Corpus Christi, Tex., **George H. Cunningham, Allen C. Jephson.** *Transactions*, American Institute of Mining Engineers (New York, N. Y.), volume 159, 1944, page 194.

Television Applications

Entertainment is just one of a great many services that television will offer the American public in the future, according to W. W. Watts, vice-president in charge of the Radio Corporation of America Engineering Products Department. In a talk on "Television's New Directions" before the Engineers' Society of Milwaukee, he outlined the roles which the medium will play in industry, commerce, law enforcement, medicine, education, and graphic communication.

In industry, fixed-focus television cameras will be used in laboratories and at critical points on production lines for inspection of materials and observation of processes and gauges in locations where explosive materials, dangerous gases, extreme temperatures, or difficult access make it impracticable to station a human observer.

Another application is the use of television for air navigation and traffic control. Radar screens showing all aircraft in the vicinity of the airport, together with transparent maps and other superimposed information, would be sent to television receivers in airplanes.

Mr. Watts told of how the medium has been applied to medical and surgical instruction, and described a process in which the camera looks down the eyepiece of a microscope and the image obtained is projected on large screens before a large classroom. He also stressed that manufacturing methods in fields ranging from heavy engineering to watchmaking can be taught to large groups via video.

Furthermore, Mr. Watts predicted that patrons will be seeing more television in the theater, and that some exhibitors will be throwing images of 15 by 20 feet or larger on their screens by the end of this year. He described a new lightweight theatre unit weighing only 50 pounds and having a $15\frac{1}{2}$-inch lens and a 20-inch spherical mirror.

Electromagnetic Induction Intensifier

The company where I work does a large business manufacturing coils of insulated wire which are linked by magnetic fields. In many of the places where these coils are used, in reactors, transformers, and in induction motors, these magnetic fields vary in time.

Engineers of my company tell me that these variable linking magnetic fields induce voltages in these coils, and that is how these coils fulfill their useful purposes in the machines in which they are placed. They say that the voltage induced in a coil, E, is equal to 10^{-8} times the rate of change of the flux-linkages Φ, or

$$E = 10^{-8}\frac{\partial \Phi}{\partial t}$$

They tell me that they calculate the flux-linkages Φ in this way. First they measure or calculate the magnetic induction, or flux density, B, at all points in space. That is, they determine the magnitude of B, and also the direction in which it points. Then starting at any point, they draw a curve following always the direction of the magnetic induction, B, and they call this curve a magnetic line, or a line of magnetic induction, or a line of flux density. They say that if they start out in a given region, and space these magnetic lines so that their spacing is inversely as the flux density strength, then they automatically retain this property, and they will bunch together just the right amount where the flux density is strong, and they will spread out just the right amount where the flux density is weak.

Having drawn these magnetic lines, the engineers then calculate the flux linkages, Φ, in the following way. Each magnetic line is examined to see how many linkages it is responsible for. If a line links one turn of the coil, then that is one flux linkage. If the line links two turns, that is two flux linkages, and so on. Add up all the flux linkages for all flux lines and you have the total flux linkages, Φ, whose variation gives the induced voltage in the coil.

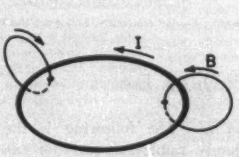
Some of the engineers say that the induced voltage in the coil is caused by these magnetic lines shrinking or expanding and cutting the turns of the coils. However, they will not tell me how to mark a particular line of force so that I can follow it around as it shrinks or expands. I put serial numbers on the coils which come over my work bench so as to detect where they go to, but I do not know how to put an identifying mark on a magnetic line. Also, I never have been able to find any mark or trace of where these moving magnetic lines cut the coil turns. So I am not so sure about these moving lines.

However, when the engineer shows me his picture of the magnetic lines, for a particular moment, I can count up the number of linkages they make and so get for the moment the total flux linkages whose time variation gives the induced voltage in the coil.

Now for my invention. I have discovered a way to multiply this electromagnetic induction effect thousands of times, by simple, inexpensive means. I will illustrate my invention first for the case of a circular one-turn coil.

Figure 1 shows two typical magnetic lines linking the coil. Each links the coil once, so that I merely need to count up the lines, based on the flux density, the way the engineers told me, and I will have the flux linkages. The flux density at each point in space will have a direction which lies in the plane passing through the axis of symmetry of the coil. At no point does the flux density have a component in the circumferential direction, or direction perpendicular to this plane through the symmetry axis.

Now I change all this by running a wire along the symmetry axis as in Figure 2. If I send current down this axial wire, it sets up a flux density which at every point is circumferential, that is, perpendicular to the planes through the axes, and at no point has a component lying in such a plane. If you run current both in the axial wire and in the circular loop, what do you get? Why your flux density at each point will have a direction which lies partly in the plane through the axis, but also partly circumferential. Now start to run a magnetic line. You go round the loop of wire as before, but after you go round once, you are not back where you started from, but you are advanced circumferentially a bit. You go around again, and still your magnetic line does not close. So you go around again, and again, and again. Every time you go around, you naturally get a linkage, and you will have to go around many thousand times before you are back even near where



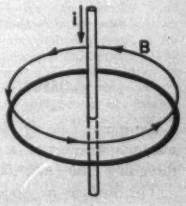
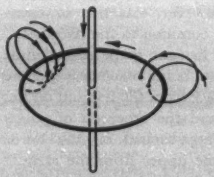


Figure 1 (left). Magnetic lines round a one-turn coil

Figure 2 (right). Flux densities produced by axial current



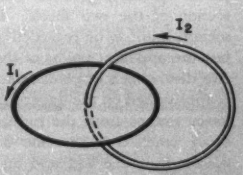


Figure 3 (left). Magnetic line linkages multiplied by axial current

Figure 4 (right). Double electromagnetic induction intensifier

you started so that there might be some chance of your magnetic line closing.

So, there you are! A magnetic line, without the axial current gives only one linkage, but with my axial current it gives thousands of linkages. Thus the electromagnetic induction is intensified or multiplied thousands of times.

For the practical application of my invention, whenever and wherever you want to use electromagnetic induction in a coil, always use two coils, connected as shown in Figure 4. Then each coil will act as an intensifier of electromagnetic induction for the other, and you will get the induction you want multiplied thousands of times.

I am writing up this invention as an electrical essay to get prompt publication, but now I have to ask a question.

Question. Is my invention any good?

J. Slepian, Alter Ego

J. SLEPIAN (F '27)

(Associate Director, Westinghouse Research Laboratories, East Pittsburgh, Pa.)

Low-Voltage Winding

Two identical transformers have a low-voltage winding that is rated at 115 volts and 60 cycles per second and is provided with 50 and 86.6 per cent taps. With a sinusoidal voltage of 115 volts at 60 cycles per second applied to the full winding the exciting current has rms components of 1 ampere fundamental, 0.4 ampere third harmonic, and negligible higher harmonics. The two windings are connected in T to a 115-volt 60-cycle-per-second 3-phase sinusoidal supply, one line connection being made to the 86.6 per cent tap on the teaser transformer. Will the three exciting currents have identical wave forms? Will they have equal rms values?

GEORGE V. MUELLER (M '35)

(Professor of Electrical Engineering, Purdue University, Lafayette, Ind.)

Answers to Previous Essays

Faraday's Law of Induction II. The following is the author's answer to a previously published essay of the foregoing title (*EE, Jul '49, p 613*).

The surface in question is shown in Figure 1 of this answer. It is 2-sheeted. Students of the theory of functions of a complex variable will recognize it as portion of a 2-sheeted Riemann surface containing a single branch point. The surface apparently crosses itself at a line of intersection of the two sheets. However, this line of intersection is not to be regarded as common to the two sheets, but the apparent points of this line are to be regarded as two distinct sets of points, one set being reached if the line is approached on the upper surface from the left and on the lower surface from the right, and the other set of points being reached if the line is approached on the lower surface from the left, and on the upper from the right.

This surface is 2-sided. If, for example, we start on the upper side of the upper sheet, and move about, as we will, on the surface, we return always on the upper side of the upper sheet. This is not true for the Moebius strip.

Figure 1. Two-sided surface bounded by 2-turn coil

Faraday's law then applies for this 2-sided surface of Figure 1. The integral of the normal component of B over this surface,

$$\int\int B_n dS = \Phi$$

has a meaning. Such an integral over such a surface is the only definition of the flux linkages Φ, which can be given in terms of operations which refer only to the coil in question, even though other electric circuits and sources of magnetic fields may be present.

A surface suitable for application of Faraday's law may be generated as follows. From any point fixed in space draw a straight line, radius vector, to a variable point on the bounding circuit curve. The surface generated by this moving radius vector, as the variable point traces out the bounding circuit, will be a smooth (except at the vertex) 2-sided surface to which Faraday's law may be applied.

Students of electromagnetism probably will recognize that if a layer of normally magnetized material with surface density of magnetization i, is placed uniformly along the surface of Figure 1, it will produce the same magnetic effect as a current i, flowing in the bounding circuit.

J. SLEPIAN (F '27)

(Associate Director, Westinghouse Research Laboratories, East Pittsburgh, Pa.)

The Steinmetz Network. The following is the author's answer to a previously published essay of the foregoing title (*EE, Jul '49, p 614*).

The Steinmetz network contains no internal electromotive force and must be energized by an external source of voltage. When the secondary terminals are open-circuited and the secondary current output is zero it follows from equation 1 of the essay that the primary voltage must be zero. This means that the network is a short circuit on the system to which the primary terminals are connected. The primary current therefore will be E_1/z (where z is the system impedance) and from equation 2 the open circuit voltage is

$$E_0 = xE_1/z \qquad (3)$$

Similarly, the impedance to be placed in series with this voltage is found to be

$$Z = x^2/z \qquad (4)$$

When the young engineer assumed a sustained primary voltage *and* an open-circuited secondary side of the network, he thereby introduced into the problem a system of infinite capacity having an impedance zero. Substitution of zero for z in the foregoing equations of voltage and impedance demonstrates that the results obtained, if not practical, are at least consistent with his assumptions.

A. A. KRONEBERG (F '48)

(Southern California Edison Company, Los Angeles, Calif.)

Conference Papers Digested for Summer General Meeting

These are authors digests' of most of the conference papers presented at the AIEE Summer General Meeting, Swampscott, Mass., June 20–24, 1949. These papers are not scheduled for publication in AIEE Transactions or AIEE Proceedings, nor are they available from the Institute.

Metalclad Switchgear Manufacture, Test, and Inspection; *B. I. Hayford (Westinghouse Electric Corporation, East Pittsburgh, Pa.).*

The use of factory-assembled metalclad is almost universal for the control of electric power distribution within the ratings available which include voltages up to 15 kv and using circuit breakers up through 500 megavolt-amperes interrupting capacity. The manufacture of this form of assembled switchgear with removable and interchangeable circuit breaker units presents many problems which are not encountered in some of the simpler forms of switchgear using fixed mounted circuit breakers. It is not only a matter of fabricating some rather complex structures involving the proper insulation and segregation of high-voltage conductors, but it also requires close control of manufacturing tolerances in both the stationary housing and the removable circuit breaker elements.

Each line of ratings requires a complete set of jigs and fixtures to control each step in the construction to hold the accumulated tolerances within close limits so that circuit breaker units of like rating can be interchanged at random. The design must be sufficiently flexible to accommodate the recognized distribution circuit arrangements without affecting the basic tool and fixture requirements.

Standard designs which can be manufactured in the fully tooled setup result in improved quality and performance. They have the background of field experience which no amount of factory testing can fully reproduce. The elements of human error in both design and manufacture is reduced by the use of standard tooled designs. When unusual arrangements are required the designer must exercise some ingenuity in adapting the basic tooled structure to avoid excessive tool expense and retain the advantages of tool controlled manufacture.

After assembly is completed, precision tool built inspection fixtures are used to gauge the removable and stationary elements to determine that the final assembly is within permissible tolerances for all critical dimensions.

When the mechanical inspection has been completed the complete equipment is given an electrical test under simulated operating conditions. Relay and instrument circuits are loaded from the primary side of the current transformers and phase relations checked. Control circuits are checked under normal operating conditions. Automatic sequences and interlocking circuits are operated. Finally, standard over-potential insulation tests are applied to all primary, secondary, and control circuits.

Guide for the Application of Low-Voltage Circuit Breakers; *Working Group for Standard 20 (J. D. Wood, Chairman)—Determination of Short-Circuit Currents.*

The proper application of low-voltage air circuit breakers with respect to its interrupting ratings, consists of determining that the maximum shortcircuit current at the point of application does not exceed the interrupting rating of the circuit breaker. Short-circuit currents are calculated at the source side of the circuit breaker (not including the circuit breaker impedance).

For direct current the maximum current is calculated. Where currents exceed 100,000 amperes, consideration should be given to rate of rise of current and speed of the circuit breaker.

For 3-phase a-c circuits, the average of the total current in the three phases, including the d-c component, is calculated of an instant one-half cycle after the short circuit occurs. It is usual to calculate the symmetrical value including the contribution of both synchronous and induction motors. The average asymmetrical current then may be determined by multiplying this value by 1.25. This method of determining short-circuit current agrees with the method used in testing the circuit breakers.

Requirements for Circuit Breakers in Cascade Arrangement. When a plurality of low-voltage air circuit breakers are connected in series in a distribution system, and the circuit breakers are applied in a correlated manner, they are said to be in cascade.

The correlation consists of a limited permissable relation of interrupting ratings, instantaneous trip setting, and circuit breaker interrupting characteristics. The cascade arrangement is limited to low-voltage air circuit breakers exclusive of moulded case circuit breakers.

No selectivity will be secured on faults near the maximum, and the circuit breaker may require major repair or replacement after one operation.

Requirements for Circuit Breakers in Selective Trip Arrangement. When a plurality of low-voltage air circuit breakers are connected in series in a distribution system, and arranged so that only the circuit breaker nearest the fault opens to clear the most severe short circuit, they are said to be in a selective trip arrangement.

To accomplish this, each circuit breaker is equipped with an especially designed overload device which gives accurate short-time delays under the highest short-circuit current. Adjacent circuit breakers have time current characteristics which do not overlap. The circuit breaker nearest the fault has the shortest delay. In addition, each circuit breaker shall have an interrupting rating and short-time rating equal to the highest short-circuit current obtainable at the point of application.

Co-ordination is required not only between the long-time and short-time delays of the circuit breakers, but often with other protective devices on the system.

Arc-Metal-Transfer Analyzer; *R. C. McMaster, D. C. Martin, A. Leatherman (Battelle Memorial Institute, Columbus, Ohio).*

Many investigators have developed laboratory techniques and instruments for the study of metal transfer in welding arcs. High-speed motion pictures, X-ray studies, tests with fast-moving electrodes, heat-transfer analyses, and studies of globules of metal transferred through welding arcs indicate that most of the metal is transferred in a molten state. Less than ten per cent of the metal transfer is estimated to occur in vapor form. Metal transfer frequencies and characteristics were found to depend upon arc current and voltage, upon electrode coatings, and other welding variables. The complex and costly methods and equipment for analysis of metal transfer in welding arcs has limited the use of such studies to laboratory research.

This paper describes a sensitive relay instrument for analyzing welding-arc short circuits caused by metal-transfer, which is a rugged and practical piece of equipment involving no electronic tubes or delicate components. It could be used in metal transfer studies under production welding conditions as well as in laboratory tests. The analyzer provides means for measuring the duration of short circuits and for counting the number of short circuits falling in each duration interval. Internal means are provided for calibrating the operating voltages and the timing of the duration of short circuits. The instrument maintains calibration for periods of many months under rugged production service conditions.

The short-circuiting of the welding arc is detected by a fast-acting Western Electric type *276G* mercury contact relay which operates in less than one millisecond. During each short circuit, this detector relay applies energy to three counting and indicating circuits and to additional circuits for cathode-ray oscilloscope calibration. The first counting and indicating circuit is actuated by each welding-arc short circuit whose duration is millisecond or greater. The second counting circuit involves an adjustable time-delay relay and can be set to count all short circuits of duration greater than any limit between 3 and 60 milliseconds as desired. The third counting circuit, similar to the second, makes possible counting short circuits above another duration limit. The simultaneous operation of these discrimination circuits makes it possible to classify the type of metal transfer in terms of the number and typical duration of short circuits.

The instrument has been used in extensive studies of welding arcs with different electrode core wires and coating constituents.

The average number of short circuits per second increases from one short circuit per second at 24 volts to 7 short circuits per second at 18 volts, when commercial 3/16-inch *E. 6012* electrodes were operated at successively lower arc voltages (and arc length). The average number of short circuits per inch of electrode burn-off increased from 10 to about 50 as arc voltage was decreased from 24 to 18 volts, with the same electrodes. In comparative studies the number of short

circuits was greatest with bare-wire electrodes, fewer with *E. 6012* electrodes, and still fewer with *E. 6010* electrodes. In most instances, the number of short circuits with durations from one to six milliseconds greatly exceeded the numbers of short circuits of longer duration. Only minor differences in the number of short circuits per second and in the turn-off rate occurred in comparative tests of rimmed steel and killed steel core wires in coated electodes. Differences in the consistency and uniformity of commercially prepared electrode coatings and small laboratory batches were revealed clearly in tests with the metal-transfer analyzer. Differences between electrode coatings were shown sensitively for electrode types for which metal transfer usually occurs during welding arc short circuits.

The rugged arc-metal-transfer analyzer appears to be of special value in studying the influence of electrode coatings, constituents, and conditions upon metal transfer during welding. It also shows, in a few seconds, some differences between operators and between manual and automatic welding equipment. Since the unit is practical for use under production welding conditions outside the laboratory, it provides a useful tool for metal-transfer studies under production welding conditions.

Operational Timing Pattern for Electronic-Resistance Welding Control; *William B. Hills (General Electric Company, Schenectady, N. Y.).*

The basic and simplest of the operational timing patterns used in resistance welding is the sequence of "squeeze," "weld," "hold," and "off," as typified by the NEMA (National Electrical Manufacturers Association) type *3B* timer and its combination counterpart the NEMA type *N2.**

Operationally only two functions occur during the sequence. The solenoid air valve applying the pressure to the work is energized during the squeeze, weld, and hold time periods. The ignitron contactor passes welding current during the weld time. These two functions generally are taken from the sequence to the form of magnetic relays (tubes sometimes are used) to energize the solenoid valve and operate the ignitron contactor. Use of the timing circuit described here permits elimination of all but the two functional relays, reducing maintenance requirements somewhat. Since no relay contacts are used in the electronic timing circuit, these irregularities are not introduced in the timing pattern.

In the timing circuit, when a thyratron operating on a-c conducts, a trailing thyratron conducts after a time delay preset by an adjustable resistance and capacitor (the capacitor is charged by grid rectification only if the preceding tube is not conducting). A third tube can be made to trail the second after a time delay and so on. This completely electronic trailing-timing action is "natural" for electronic timing of the sequence of resistance welding.

Features easily provided by this type of circuit are: nonbeat to prevent halting the sequence in the middle of a welding operation; nonrepeat switch permitting only one operation each time the initiating switch is closed; no-weld switch to permit sequencing without weld current flow; low-voltage (24-volt) initiating circuit for operator protection and inherent 2-stage foot switch operation, if desired, to permit applying pressure before the sequence is begun.

Other operational timing circuits flow easily from this basic form. The 3-phase frequency converter uses basically the same sequence, except that during the weld time a sequence of positive and negative heat and cool times control firing thyratrons and ignitrons to give the flip-flop half-wave rectification pattern which is characteristic of 3-phase to single-phase frequency conversion.

Hence this timing circuit is the means of operational timing patterns for electronic control of resistance welding.

* "Squeeze" is the time between the application of pressure to the work and the beginning of the weld current. "Weld" time is the duration of the welding current flow. "Hold" is the time after current flow in which pressure remains applied for the cooling of the weld. During the "off" time pressure is removed and new work is inserted.

Electrical Advantages of Low-Frequency Welding Converters; *C. B. Stadum (Westinghouse Electric Corporation, Buffalo, N. Y.).*

Since there is now increased activity in the aircraft industry, welding machine manufacturers again are reinvestigating all the possibilities of welding control systems that will weld aluminum most satisfactorily. One system which has an extremely promising future is the low-frequency converter system, since it provides both welding and electrical advantages.

This system provides such advantages as the following:

1. It lowers the kilovolt-ampere demand to about 50 per cent of the original demand.
2. If the system is a 3-phase system, it divides the demand on three lines.
3. It reduces currents to approximately 25 per cent of the line current of an equivalent single-phase line-frequency welder.
4. It reduces "spitting" at the electrodes and greatly reduces electrode "pickup" in aluminum welding.

In addition to the foregoing advantages, many improvements have been made recently which simplify both the aluminum welding technique and simplify design of welding transformers. Up to this time a "banging" has occurred in low-frequency transformers if the welding machine had a low power factor or if the magnetizing current was high relative to the load current. This "banging" is a brief short circuit on the transformer. Circuits have been invented recently which will eliminate short-circuiting in spite of low power factor welding machines.

Although the new circuits allow the welder manufacturer greater leeway in their designs, the greatest advantage is to the user; in electrical terms there is a "zero current gap" between the individual half cycles of current in a low-frequency system. The gap is undesirable in welding aluminum since the growing weld nugget cools during the "off" period. The cooling period often makes the first cycle of welding current the only effective one. Up until the present time, the amount of gap has been a function of the power factor of the welding machine and consequently the gap has varied from machine to machine. However, now the gap can be reduced to zero which means that there is continuous heating of the weld.

Not only does the elimination of the gap produce better welds, but it further balances the line currents in the 3-phase system. This is the result of a new electronic circuit which controls the duration of the individual pulses of current supplied by the 3-phase lines.

The ECPD Accrediting Program; *Donald B. Prentice (Rose Polytechnic Institute, Terre Haute, Ind.).*

An important reason for the establishment of the Engineers' Council for Professional Development in 1932 was the chaos that threatened in the possible accrediting of engineering schools by 48 separate state licensing boards. Every registration law for professional engineers gives an applicant a certain time advantage for college training received at an "accredited" institution. In 1932 there was no accepted list of accredited engineering schools comparable to those of the American Medical Association and the American Bar Association. Accrediting properly done necessitates some interference with college routine and some compilation of factual information. Administrative officers of engineering schools could foresee many hours of work as the requirement of registration for professional engineers spread from state to state.

In its charter the ECPD proposed among other items, "To formulate criteria for colleges of engineering which will insure to their graduates a sound educational foundation for the practice of engineering." To carry out this phase of its program the Council established a standing "Committee on Engineering Schools" of which President Karl T. Compton of the Massachusetts Institute of Technology became chairman. This committee prepared a "Basis for Accrediting Colleges" which was approved by the Council in October 1933. So much careful consideration went into the preparation of this plan and so experienced in engineering education were the members of Dr. Compton's committee that in 16 years of practice only minor changes have been introduced in the program.

The basic principles which have been largely responsible for the satisfactory operation of the accrediting program include accrediting of curricula rather than of schools, inspection of curricula by competent examiners on invitation of the college authorities, avoidance of rigid standards and reliance on inspectors' judgment, and publication of an approved list without comparative ratings.

Of approximately 170 degree-granting engineering schools in the United States, about 145 have requested inspection and offered some 700 curricula for approval. Many curricula were endorsed immediately, others passed on second examination, and the accredited list now includes about 85 per cent of the curricula which have been examined. Not all of these curricula have unconditional approval from ECPD, but the published list makes no distinction between full and temporary accrediting. Provisional endorsement pending certain improvements has been a useful means by which the committee could assist an engineering college dean in securing needed and deserved institutional support.

The accredited list of ECPD, through the constituent members of the Council, carries the authority of the engineering profession. The list is accepted by all state examining boards, by graduate schools, by industry, by

bureaus of the United States Government, and by college advisers and students in secondary schools, as well as by the national societies themselves. Revising the list by periodic re-examination is a responsibility of the Committee on Engineering Schools but other activities of the committee, for example the accrediting of technical institutes, are increasing in importance as the program is carried on "toward higher professional standards of education."

Characteristics of Some Magnetic-Fluid Clutch Servomechanisms; *A. J. Parziale, P. D. Tilton (Massachusetts Institute of Technology, Cambridge, Mass.).*

Magnetic-fluid clutches offer a new and promising type of servomechanism because of their simplicity, fast action, ease of control, and their advantages over other clutches in freedom from wear, chatter, and critical adjustment. Tests of two different, disk-type clutches rated at 35 and 80 inch-pounds of torque exemplify the good dynamic capabilities of the new clutch and indicate some effects of the clutch's characteristics upon its performance in closed-loop systems. The small clutch, a Raymond Engineering Laboratory model *731*, is more nearly representative of design for practical use than the larger experimental model, which was designed at the Massachusetts Institute of Technology Servomechanisms Laboratory for a basic study of the static and dynamic characteristics of the magnetic fluid.

The magnetic properties of the iron-oil mixture have not been fully established, but the permeability seems to be fairly constant and four to eight times that of air. With a nine-to-one ratio of iron to oil (by weight), the average shear stress resistance developed between clutch faces is proportional to the gap flux density raised to some power greater than the first but no more than the second. Some variation in this relationship is observed for different gap spacings; larger gaps produce less shear stress for the same flux density. The magnitude of the stress is affected only slightly by the rate of shear. A lower permeability and some reduction of shear resistance are to be expected with thinner mixtures.

The steady-state torque-current characteristic for a single clutch is dependent upon the magnetization curve of the iron core and is modified by the magnetic and shear stress properties of the magnetic fluid. It exhibits saturation, hysteresis, and a residual drag. Magnetic-fluid clutches are not instantaneous, but have a small time lag whose dependence upon iron concentration, fluid properties, gap spacing, shear rate, and clutch size or design has not been completely investigated.

Agreement between sinusoidal frequency-response tests and transient responses showed an average time constant of about 0.08 second for the large experimental clutch and less than half this for the Raymond *731*. The faster response time of the latter may be due to its thinner iron-oil mixture treated with a surface-active wetting agent, more efficient magnetic core, and much smaller clutch gap. In both clutches the time constant for increasing torque is about twice as long as that for decreasing torque.

The dynamic performance of the two clutch models was determined from sinusoidal frequency-response measurements of a closed-loop servomechanism which employed synchros for position reference and d-c tachometer feedback for stabilization. The servomotor was comprised of two identical clutches opposing each other to obtain a push-pull effect which balances the zero-signal drag torques and produces a reversible net output torque that is proportional to the differential coil current. The magnetic-fluid clutch approximates a torque-source because its output torque is virtually independent of rotation speed, but the 2-clutch unit showed a slight amount of damping which is indiscernible in a single clutch. The servomechanism with the experimental clutch had a flat positional response for sinusoidal frequencies up to 12 cycles per second, while that with the Raymond *731* clutch followed frequencies up to 30 cycles per second. Both clutch servomechanisms exhibited good system stiffness and low steady-state velocity following errors without exceeding a peak amplitude ratio, output to input, of 1.8.

The magnetic-fluid clutch appears to be well suited to servomechanisms of almost any power rating, but life and service limitations must be overcome before widespread use will be possible. Large torque-to-inertia and power-amplification ratios can be attained, but application requiring much heat dissipation cannot take full advantage of the small size and simplicity of the clutch. Problems of heating, sealing, and settling of the iron-oil mixture call for continued research and investigation, but they are not insurmountable and the advantages of this new clutch warrant its continued development.

What the ECPD Visitor Sees; *Edward L. Moreland, former member ECPD Committee on Engineering Schools (Jackson and Moreland, Boston, Mass.).*

It is presumably well understood that the immediate objective of an inspection by an Engineers Council for Professional Development regional committee is to determine whether the engineering curricula offered for accrediting qualify for inclusion in the list of accredited curricula maintained by ECPD for the benefit of state licensing boards, professional engineering societies, and others. The longer range objective, and the basic objective of ECPD, is to raise the standard of engineering education and practice.

Inspections are carried out by committees of experts in the fields of the various professional curricula offered for accrediting. The majority of the inspectors are usually men in educational work, but in a well-balanced committee there always will be at least one man with wide industrial or professional experience. Considerable statistical and factual information will have been supplied to the committee in advance.

There is no set procedure for the examination but a common pattern is for the committee as a whole to meet first with the dean of engineering for a brief discussion of his philosophy of engineering education and then for the committee to split up, and each individual member then proceeds with the examination of the professional curricula and the supporting subjects assigned to him. Individual conferences are held with department heads and as many as possible for the departmen staff. Laboratories are inspected; laboratory methods of instruction are inquired into; students' laboratory reports are examined; textbooks used, examination papers, quiz papers, and problem assignments are examined; all in an effort to ascertain the level of the work the students are doing, how much they are learning, and above all, whether they are learning to think for themselves. By far the most significant item in this procedure is the conferences with the staff members, particularly the department head whose ideals and standards set the pace for the department. These conferences often will show whether emphasis is on the read-the-book, follow-instructions, deep-in-the-rut type of instruction, perhaps meticulously thorough, or whether emphasis is on leading the student to think for himself and develop habits and methods of study which will be applicable to any problem. The curricula are judged not only on their technical content but on the over-all educational program, including cultural and social studies, designed to give the young engineer some appreciation of his obligations to society and the engineering profession.

Unusual Applications of the Cathode-Ray Oscillograph in the Electrical Industry; *P. S. Christaldi, W. G. Fockler (Allen B. Du Mont Laboratories, Clifton, N. J.).*

The cathode-ray oscillograph for many years has played an important part in electrical engineering studies. The extremely versatile and useful refinements which have been devised to accelerate the development of radar, communications, and nuclear studies, however, have not been so fully and advantageously exploited in other fields of electrical engineering as they might be. The performance of cathode-ray tubes has been improved both in fluorescent screen characteristics and in gun design. Cathode-ray equipment design has kept pace and now permits the study of a much wider range of phenomena than ever before. Improvements in techniques as well as in equipment are of interest to the electrical engineer.

It is interesting to note that many types of measurements which the engineer has been called upon to make over the years can be made much more readily and often much more accurately by suitable choice of new equipment and techniques. Displays of the polar co-ordinate type, for example, are useful in the study of rotating machines, since they lend themselves to relating phenomena to shaft angle, and since they can be made to give constant angular disposition of the display independent of instantaneous speed changes. Multichannel presentations, using cathode-ray tubes having several independent electron guns, are useful in comparing several simultaneous phenomena such as welding electrode pressures, currents, voltages, and timing.

Many applications require the measurement of voltages that vary rather slowly, and in such cases the use of continuous film recordings from the face of the cathode-ray tube permits the collection of data over long time intervals but with good time resolution. In some instances a related technique combining film motion and cathode-ray tube sweep for the production of expanded time bases may be found advantageous.

The measurement of wave forms and durations of impulses has received much attention in the fields of electronics and nucleonics as well as in the power industry. New techniques and equipments have been developed, especially the use of scaled-off cathode-ray

tubes, electronic sweep circuits, improved trigger, delay, and timing circuits, and so forth, which are especially valuable in electrical engineering. By their use, measurements of impulses lasting fractions of a microsecond may be made readily.

Problems in Health Physics Instrumentation; *Samuel Levin* (*Massachusetts Institute of Technology, Cambridge, Mass.*).

The comparatively new field of radiation protection, or health physics, now has reached a fairly satisfactory position in its progress towards providing methods and instruments for the control of radiation hazards associated to work in nuclear physics. The so-called "radiation worker" now may enjoy as large a safety factor as a worker in any other occupation.

This safety factor depends on three basic health physics principles:

1. Understanding the nature of the radiation.
2. Employment of the necessary shielding to maintain a safe radiation level.
3. Employment of proper instruments to monitor personnel.

Many electrical engineers now are engaged in the design, construction, and installation of high-energy accelerators of which, perhaps, the Van De Graaff generator is the best example. The Van De Graaff generator is capable of producing several types of ionizing radiation, depending upon whether electrons or positive ions are being accelerated. The usual Van De Graaff generator accelerates electrons. The electron beam itself or the X rays generated when the beam is allowed to strike a target is, of course, a potential radiation hazard. Positive ion Van De Graaffs are important tools for the study of nuclear reactions. With the proper selection of target, neutrons are emitted. The acceleration of positive ions usually is accompanied by the undesired liberation of electrons and the production of X rays.

Shielding for the vertically installed electron-accelerating Van De Graaff is facilitated by locating the target room below ground level. Horizontal installations increase the shielding problems. Positive ion Van De Graaffs are inherently more difficult to shield, due to the neutron hazard and the location of X-ray production.

The instrumentation necessary for monitoring personnel should include the following:

1. An ionization-type radiation monitor with outlets to actuate an alarm system and to accommodate a continuous recorder.
2. Radiation safety-film badge service for all personnel.
3. Self-reading pocket ionization chambers for all personnel.
4. A fast neutron survey meter.

The lack of commercially produced fast neutron survey meters is a matter of much concern. Present methods of measuring fast neutron flux include BF_3 proportional counters, proton track counting in emulsions, and arsenic button activation.

Some Electronic Aids to the Nuclear Physicist; *Emil De Agazio, Jr.* (*Massachusetts Institute of Technology, Cambridge, Mass.*).

In any list of the many electronic devices which have found extensive application in nuclear physics instrumentation, one would be almost certain to find the following: wide-band linear amplifiers, amplitude discriminators, coincidence (and anticoincidence) circuits, scaling and register-driving circuits, pulse-forming circuits, delay lines, pulse generators, and oscilloscopes having "slave" sweep circuits. A multichannel amplitude analyzer contains some forms of all these devices either as integral parts of the instrument itself or as associated test equipment. The analyzer, then, is a useful example of an over-all instrumentation setup in nuclear experiments.

The multichannel amplitude analyzer (sometimes called a differential pulse-height discriminator) finds its particular application in determining directly differential bias curves in connection with the study of the energy distribution of nuclear reactions. It permits the taking of data in one day which otherwise might take weeks to acquire.

Essentially, the analyzer sorts pulses from an electric detector of radiation according to height into several channels of equal width. Pulses from the detector (for example, an ion chamber) are applied to the input of a linear amplifier. The amplifier, which contains a delay-line pulse-forming network, supplies pulses of amplitude and shape suitable for counting to a series of n simple amplitude discriminators whose bias settings increase in equal steps. Anticoincidence circuits between the discriminators determine the scaling circuits which will be operative, and hence the channel in which a pulse is recorded. A series of triggered blocking oscillators and delay lines supplies pulses with proper timing for operating the chains of scales-of-two, and for returning the discriminators to their original states after counts have been recorded.

A special test unit, the "sliding pulser," is associated with the analyzer. In the condition in which it supplies pulses whose heights may be adjusted so that each channel in turn is operative, the sliding pulser is used for testing the operation of the discriminators, anticoincidence circuits, scalers, and so forth. In its second condition, when it supplies "sliding" pulses, that is, periodically occurring pulses whose amplitudes alternately increase and decrease, the pulser is used to adjust the channels for equal widths. An oscilloscope containing a slave sweep circuit completes the test equipment associated with the analyzer.

In an n-channel analyzer, $n+1$ items of data, n of which are independent, are obtained simultaneously. These include a total count of all pulses of amplitude greater than a given minimum value, a count of the pulses of amplitude greater than a given minimum value, a count of the pulses whose heights fall within $n-1$ adjacent channels, and a surplus count of pulses whose amplitudes are too great to fall into the highest channel. Since these data can be taken with great rapidity, the instrument is especially valuable where the operating cost of a large accelerator is considerable.

Thickness Gauges in Industry Employing Radioactivity; *J. R. Carlin* (*Tracerlab, Inc., Boston, Mass.*).

The continuous measurement of the thickness or weight per unit area of materials in production has been successfully accomplished by employing radioactivity. When the material under investigation is accessible from two sides, an absorption method is employed where the material in question is caused to flow between a radiation source and a detector. The measured degree of absorption of the nuclear radiation provides an accurate indication of the weight per unit area of the absorbing material. If the specific gravity of the material is known, an indication of thickness can be afforded. The choice of isotope for a particular application depends upon the range or thickness to be measured, remembering that the most ideal isotope is that which generates greatest detector response and provides the steepest and most linear section of its absorption characteristic over the desired range. In addition, cost consideration, half life, and health hazard are important factors. Although absorption characteristics, describing detector response versus weight per unit area of absorber, resemble exponentials, it is possible to achieve excellent linearity within small sections of these characteristic curves.

In many industrial installations of thickness gauges it is desirable to have the results appear on a recorder chart. In addition, the use of a self-balancing potentiometer recorder makes possible a method of automatic standardization by modifying the usual feature contained in standard recorders for automatically standardizing the slide-wire potentials.

When the material under investigation is accessible from only one side, or when it is superimposed on another material of different atomic number, it is still possible to achieve an accurate measure of thickness or weight per unit area by employing the principle of beta ray backscattering. In this application both the source and radiation sensitive detector are located on the same side of the material. The intensity of radiation scattered back to the detector is a function of the thickness and atomic number of the unknown target material. Here again, the choice of isotope depends primarily upon the range of thickness to be measured.

Application of Microwave Radio to the Bonneville Transmission System; *T. W. Stringfield* (*Bonneville Power Administration, Portland, Oreg.*).

An 8-channel multiplex microwave radio relay system extending 200 miles along the 230-kv transmission system between the Puget Sound and Portland, Oreg., areas will be installed during the summer of 1949. The equipment will be furnished by Federal Telecommunications Laboratories, Inc. This is the initial installation of a system that it is expected ultimately will cover the entire 230-kv system.

Channels are provided for telephony, telemetering, power line relaying, and automatic fault locating.[1]

Reliability was a prime consideration in the design. All transmission paths provide at least 100-foot clearance based on true earth's radius. Duplicate radio-frequency equipment with automatic switchover is installed at all stations, and in addition, the standby receiver is connected to provide vertical space diversity reception on the longer paths. Primary power to all stations is from nearby commercial systems or substations. Small gasoline-engine-driven generators will be installed at unattended relay stations. As a further precaution to insure that micro-

wave channels assigned to power line relaying will function during system fault conditions, standby power in the form of 125-volt storage batteries and inverters kept spinning will be available at all stations. The d-c power supplies of the radio and multiplexing equipment will have sufficient storage to allow for time of switchover to standby power. Finally, one channel is employed as a service channel to transmit alarm signals to the terminal stations for primary power failure and equipment failure at the repeater stations. Also, the service channel provides means for locating a faulty station by testing from the terminal stations.

The application of a multiplex microwave radio system to an extensive power transmission system is complicated by the requirements for waystation service. Such service requires demodulation to audio frequencies. As the number of such stations connected in tandem increases, there is a corresponding increase in the severity of design requirements in consideration of noise, distortion, cross-talk, and channel attenuation. These factors must be considered and specified initially to preclude restrictions on the future growth of the system.

The greatest benefits to power system operation appear to lie in the application of microwave to power line relaying. Bonneville expects materially to increase the stable load limit of the 220-kv system by simultaneous high-speed relaying of both ends of a faulted line section over the microwave channels. This will make it possible to apply fast reclosing with additional increase in the load limit.

REFERENCE

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A Place for Microwave Radio in the Power Industry; *D. R. Pattison (Pennsylvania Electric Company, Johnstown, Pa.).*

The Pennsylvania Electric Company operates in a territory in western Pennsylvania consisting of approximately 12,700 square miles, extending from the Maryland–Pennsylvania state line northerly to Lake Erie, and covering all or part of 21 counties. Eight major and six minor generating plants serve more than 275,000 customers over 11,500 circuit miles of primary transmission and distribution lines. The main generating plant is located at Seward, Pa., ten miles west of the operating headquarters at Johnstown. Since the establishment of this plant in 1922, maintaining communications between it and operating headquarters has been a constant problem.

Originally, two open-wire private telephone circuits installed under the 25-kv transmission line served the purpose in a fashion. So communication with other plants could be carried on, a number of combination open wire and cable circuits were leased from the local telephone company. Through the years these have proved very unreliable and, usually when most needed, have become sadly disrupted. On several occasions interruptions of as long as 36 hours on all open wire circuits have tied up system operations.

With the need for expanding these facilities and improving on the reliability so that additional telemetering, supervisory control, and pilot wire relaying systems could be provided, we approached the local telephone company officials for suggestions, but without avail. Therefore we were faced with either installing our own cable circuit or some other multichannel facilities, preferably radio.

Our long experience with various types of cables have proved them to be vulnerable to all sorts of trouble, especially gunshot, landslides, icing, and auto traffic, all of which would be eliminated by the use of radio. We then made an investigation of the possibilities of a radio link. The Federal Communications Commission encourages the use of as high a frequency as possible for point-to-point operations in order to avoid congestion and interference. It was decided that the only frequency that appeared feasible was the 940- to 960-megacycle band, although our preliminary tests showed that the 75-megacycle band would have the least complications, for the reason that although relatively high in frequency it was not strictly line of sight and did bend or reflect from natural surfaces and did not require cable extensions or special repeaters or reflectors at the Seward end.

The Westinghouse Electric Corporation was consulted on this problem as they manufacture and apply telemetering, supervisory control, and special relaying equipment. A temporary testing station was constructed a short distance from the Seward plant and a 2-way 950-megacycle radio link was established between the testing station and Hilltop substation. This link required facilities for four 2-way voice channels and 30 telemetering channels.

Voice-frequency telegraph equipment is available to allow ten telemetering channels to operate on one voice channel, making the total requirements for the Seward to Johnstown link seven voice channels. The actual band width required for any one channel depends upon the number and type of modulating signals. One of the purposes of this experimental program is to determine the band width requirements for different signals. The manufacturer believes their equipment will provide all the circuit demands in a width of 400,000 cycles.

The particular problem involved in the application of strictly line-of-sight radio is that there is not a direct line-of-sight path available between the Hilltop substation and the Seward plant. Our studies of topographic maps and other data showed that a line of sight was apparently possible from the Hilltop substation to a point about $2^1/_4$ miles north of Seward station, which would require at least $2^1/_4$ miles of cable extension. Since this gap in the Allegheny Mountains is very narrow even at higher elevations, there was a 3-month wait before the atmospheric conditions cleared sufficiently visually to check this path. It was wondered what effect this would have on the radio beam. However, our tests have proved conclusively that the circuit is very reliable in all weather conditions, even including heavy snowstorms.

As mentioned before, the Seward plant not being in direct line with Hilltop and wishing to eliminate the cable extension checks with reflectors or passive repeaters, were made immediately. The first experimental reflector was mounted at the same location as the original Seward terminal and consisted of a 20 foot square mesh screen. Although the beam could not be reflected directly into the Seward plant, the initial tests showed that a very usable signal could be reflected. A reflector location which would be in the direct line of sight from both stations was found about one mile from the test station toward Johnstown. The site is quite isolated and is not accessible during the winter months. However, we feel that the reflector will require little or no maintenance and accessibility will not be a problem.

In order to eliminate the cable extension at the Johnstown terminal, we are seriously considering the moving of the Johnstown operating center from the downtown office building to the transmitter location at Hilltop substation. This will have the added advantage of eliminating cable extensions to our frequency-modulation terminal and will provide a site from which other microwave channels can radiate to other parts of the system.

Because of our vast system of private communication facilities including common telephone, carrier telephone, carrier relays, and licensed radio equipment, competent and fully equipped crews of technicians are available to service any proposed equipment. The main purpose of radio equipment would be to provide a foolproof all-weather link between the system operator's center and the Seward plant with its battery of converging power circuits and system wide communication equipment.

A Development of Microwave Equipment for Power System Applications; *M. H. Wood, Frank B. Gunter (Westinghouse Electric Corporation, Baltimore, Md.).*

The continuous growth of power systems has increased the demands for communications facilities to the point where carrier current, leased and private wires, and low-frequency space radio cannot suffice. The use of microwave equipment for point-to-point application can alleviate some of this crowding and in addition can offer increased facilities for supervisory control, telemetering, voice communications, and protective relaying which probably would be uneconomical at the lower frequencies.

A survey of power systems in the country indicated that the basic requirement at microwave frequencies for line-of-sight operation was not too serious a limitation in the application of microwave equipment. An investigation into the characteristics of microwave propagation and of microwave components resulted in the conclusion that a relatively narrow band system operating at lower microwave frequencies would be adequate for most power system applications.

A development program having the following objectives was carried out:

(*a*). The equipment should operate over line-of-sight distances of at least 35 miles.

(*b*). The equipment should be as simple and as dependable as possible.

(*c*). It should be capable of handling up to seven voice channels or up to 55 telegraph circuits with signal-to-noise ratios corresponding to good commercial practice on wire lines.

(*d*). The equipment should be of unit-type construction requiring a minimum of accessory equipment to set up a complete station.

(*e*). Cost and selling prices should be reduced wherever possible without jeopardizing dependability.

(*f*). Tubes and maintenance cost should be kept at a minimum.

The equipment developed under this pro-

gram consists of a phase-modulated 940-960 transmitter having a rated output of five watts, a double superheterodyne receiver designed particularly for low noise operation, power supplies, and audio multiplexing equipment using frequency division multiplexing. Field and laboratory tests of the equipment indicate that the objectives of the program have been met. Four stations are in operation on a 24-hour-a-day basis to determine the dependability of the equipment under operational conditions.

Upper Air Meteorological Telemetering; *Bradford K. Hawes (National Bureau of Standards, Washington, D. C.).*

The expansion of aviation and other industries together with the acceptance of the air mass theory of 3-dimensional weather forecasting have required new techniques for obtaining upper air data. Radiosonde telemetering systems have been developed to answer this need. Small lightweight radio transmitters incorporating suitable meteorologically responsive instruments are carried aloft by free balloons. Soundings of the the atmosphere to heights of 20 miles are made with these radiosondes. Records of the atmospheric conditions encountered are made on the ground for use by meteorologists in preparing forecasts.

Since the First World War three basic types of radiosonde systems have been developed. They are

1. Interruption of carrier signal (P.P.M.).
2. Variation of the carrier frequency (F.M.).
3. Variation of modulation frequency (subcarrier F.M.).

The third system is used almost exclusively in the United States. This system operates by the translation of a multiplicity of thermodynamic, hygrodynamic, barometric, and so forth, properties of the atmosphere into correlated electrical resistance values, of resistances into audio frequencies which modulate a radio carrier, and at the ground station, finally, of audio frequencies into recorder chart divisions.

The subcarrier system is superior to the other two in that it meets most of the criteria applicable to the evaluation of such systems. These critiera are

1. The precision of the measurements should have a minimum dependence upon stability of the electronic circuits employed.
2. It should be possible to calibrate the meteorological instruments independently of the electric circuits with which they are used.
3. An effectively continuous recording of all meteorological variables should be possible.
4. It should be possible to add instruments to the airborne equipment without modification of field installations and procedures.
5. It should be readily adaptable to use the widest variety of input transducers providing electric outputs.
6. Cost, weight, tube complement, battery requirements, and the like, should be kept to a minimum.

An improved radiosonde system has been developed. Essentially continuous records of six or more instruments are made by use of high-speed recorders and by scanning the instruments in rapid sequence in the balloon-borne equipment.

An analysis of the inherent systematic errors has been conducted. These are primarily the basic errors in the instruments, errors in the radiosonde's blocking oscillator, and errors in the recording system. The instruments change resistance in accordance with atmospheric conditions. They are sequentially connected into a blocking oscillator circuit and vary its blocking rate. This blocking oscillator has an essentially linear period versus resistance relationship. The errors in the determination of atmospheric measurements may be evaluated by considering each of the afore-noted errors. From these the over-all errors may be derived, since the sensitivities of the conversions from the atmospheric variables under question into cycles can be found.

Several problems remain to be solved which are germane to the future progress of radiosonde development. Micro-meteorology has demonstrated highly unstable atmospheric conditions to prevail within areas of a few feet. In view of these and other measurement uncertainties, the statistical significance of widely scattered soundings must be questioned. Therefore, the usable precision of any radiosonde system is dependent upon the method of its application.

A Pulse Width Telemetering System; *W. Hausz (General Electric Company, Syracuse, N. Y.).*

Telemetry system described was designed in 1945 and 1946; improvements, new ground stations, and operating experience were added in 1947–48. Survey of the needs of groups involved in the particular guided missile project showed some 20–30 channels were needed, with but a moderate sampling rate. The design was based on the need, in small guided missiles, for lightness, compactness reliability, reasonably low cost. Twenty-eight channels mechanically commutated are converted from a 0-5 volt d-c input to a variable pulse length 100 to 700 microseconds long. This is transmitted via carrier shift modulation from missile to ground.

Special features of reliability, convenience, and flexibility are given in the ground stations by three methods of presentation. The variable length pulses are put on the intensity grid of a cathode-ray scope which is photographed on a moving film strip. In one presentation a fast sweep is started on the leading edge of each pulse so all information is displayed as a raster of lines of different lengths. In another display, one slow sweep displays 28 pulses, one sample of each channel. The third display type consists in separating the channels into groups of seven, differentiating so only a bright pulse on the trailing edge is displayed. This gives the appearance of conventional time base plots. Time markers, and channel identification by brightening each one in turn, add to convenient use.

A large number of operational flights have been made with successful results, little time being lost due to primary telemetry failure.

An FM/FM Telemetering System; *W. J. Mayo-Wells (The Johns Hopkins University, Silver Spring, Md.).*

The measurement and recording of physical quantities in a moving vehicle is not always practical by a wire link, especially if the vehicle may be destroyed or excessive conditions might damage the records. For such applications a radio link provides an answer, and increased security can be obtained by duplicating the receiving stations as an added advantage.

The first FM/FM telemetering system was developed under National Development and Research Council, and many systems have followed from this original. While the principal differences concern the choice of audio frequencies for the various subcarriers and methods of commutation, the majority of these systems operate on the principles well-known in frequency telemetering by wire circuits.

The system to be described exploits the use of a small *E* type inductance coil, which forms part of a Hartley or Colpitts audio oscillator. A moveable mu metal armature varies the inductance according to its position with respect to the coil, which in turn varies the oscillation frequency. This movement has been employed to measure a variety of physical quantities: motion, acceleration, pressure, and so on.

Other types of audio oscillators are used to measure voltages, temperatures, strains, and vibrations. Suitable pickups have been devised for use with each type.

The outputs of a number of pickups or a number of subcarrier oscillators may be commutated, and some of the limitations governing the length of samples and the frequency response are given. The complex audio signal modulates a reactance tube in a conventional frequency-modulation radio-frequency transmitter.

After being detected in a frequency-modulation receiver with a Foster Seeley discriminator, the subcarriers are separated by band-pass filters with a band width of 15 per cent around each center subcarrier frequency and translated into d-c signals by pulse averaging audio discriminators. These d-c signals, whose instantaneous amplitudes are proportional to the original instantaneous frequencies of the subcarrier oscillators, drive a magnetic oscillograph recording on film.

The whole transmitting equipment is designed to withstand extreme physical conditions for a short duration, and to occupy as small a volume as is consistent with reliability and the required accuracy. The transmitting system is composed of very compact plug-in units, which may be combined in a great variety of ways to suit the precise needs of the particular vehicle. Complications are better introduced in the receiving stations which are not expendable.

A very complete system of technical information is being executed, which includes design, type test, and production specifications, together with component data sheets, application information, and so forth.

A New Loss-of-Excitation Relay for Synchronous Generators; *C. R. Mason (General Electric Company, Schenectady, N. Y.).*

Interest has been growing in loss-of-excitation protection for synchronous generators, particularly where light-load operation with reduced excitation makes impossible the use of field undercurrent and undervoltage relays. Many differential-analyzer studies have been made of the loss-of-excitation characteristic, and these combined with recent relay developments have resulted in a simple relay having greater selectivity than heretofore has been available.

The new loss-of-excitation relay is of the so-called "mho" family, similar to distance relays used for transmission-line protection.

It is a single-phase relay arranged to operate from a phase-to-phase voltage and the difference between the phase currents at the terminals of the generator to be protected. The operating characteristic on the $R-X$ diagram is a circle centered on the $-X$ axis and offset completely from the origin. The diameter of the circle and the offset are independently adjustable.

If the offset is approximately one-half of the direct-axis transient reactance of the generator, and if the diameter is approximately the direct-axis synchronous reactance, the relay will operate for all cases of complete loss or substantial reduction of excitation, and will not operate for any other kind of normal or abnormal system-operating condition. Operation will occur before the first pole is slipped.

The impedance "seen" by the relay for various conditions, and the area within which this impedance will operate the relay when shown on an $R-X$ diagram clearly demonstrate the relay's selectivity. Loss-of-excitation characteristics start outside of the operating area and enter it at varying times after the excitation is affected, but always before the first pole is slipped. Loss-of-synchronism characteristics never enter the operating area except for substantial reduction of excitation. Line charging within the line-charging capacity of the generator will not cause operation, nor will short circuits even on the generator bus.

Protection cannot always be provided against partial loss of excitation without running the risk of operation during power swings or loss of synchronism. Where such protection is required, the relay should merely operate an alarm rather than trip the generator circuit breaker. Short-circuiting of part of the field poles can cause damaging vibration, and other protective means should be employed.

An interesting use of the $R-X$ diagram is to show the characteristic of the "reactive-current" relay described by Crossman, Lindemuth, and Webb.[1] It will be found except that it has no provision for offset and was given a different adjustment, its characteristic is like that of the relay described herein. This is only one of many possible illustrations of the value of the $R-X$ diagram in analyzing relay operation under various system-operating conditions.

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Practice and Extent of Loss-of-Excitation Protection on Rotating Machines; *G. B. Miller* (*Duquesne Light Company, Pittsburgh, Pa.*).

The material presented in this paper is the result of a study made by the Relay Subcommittee of the Pennsylvania Electric Association to determine the practice and extent of loss-of-excitation protection as applied to synchronous generators. Recognizing that serious damage may be caused to an alternator as the result of loss of excitation, a study on this general subject was thought to be beneficial at this time due to the great amount of new generation being installed.

The conclusions reached from the study are that for moderate size utilities, as encountered in Pennsylvania, the absence of loss-of-field protection is not a serious matter. In the 15 companies reporting, no apparent damage was observed on any machine from having had field failure. Only 40 per cent of these companies report using loss-of-field protection. The schemes used are comprised, predominantly, of an undercurrent relay in series with, or an undervoltage relay in parallel with, the field.

This decision is amplified further as out of 64 loss-of-field installation reported, the majority of these only provide an alarm thus requiring the operator to clear the machine from the system.

In contrast to these small to moderate size utilities, where loss-of-field protective installations appear to be debatable, field failure relays are found to be a necessity for the larger metropolitan cities. Here the generators usually are linked closely together with cables and operate at relatively high power factors. For this condition pull-out power is low with the result that instability may occur at times of light load for loss-of-excitation on a large generator. In general, for such cases loss-of-field relays are not considered to be as essential to protect the machine as they are to protect the system from loss of stability. In the final analysis, the important point is to disconnect the machine from the system as quickly as possible. By this action the machine will be protected from damage and at the same time the system may be protected from instability.

It is generally recognized that undercurrent and undervoltage relays do not provide full coverage, as it is necessary to set these relays to operate at values well below no-load excitation. To overcome these objections, for systems that do need sensitive loss-of-field protection, a new scheme was developed several years ago and is comprised of a polyphase directional overcurrent relay that acts on the flow of reverse reactive current into the generator during the conditions for loss-of-excitation. The scheme has proved to be satisfactory as demonstrated by the company using it. Twenty-six of these installations are in service on turbogenerators of 40-megawatts and larger capacity.

At this time, a new distance-type relay of the "mho" family is being announced for loss-of-field protection and is claimed to be competitive to the reverse reactive current relay scheme. Operating data are not available as yet, however, one company reports it is contemplating the use of this relay on two 75-mw units.

The installation of loss-of-field relays may be likened to buying insurance. As systems become more complex and interconnected, it places a greater responsibility on the station operator properly to diagnose a field failure and take the necessary action to clear the machine. For systems where instability is likely to occur for loss of excitation, certainly there is no doubt that complete loss-of-field protection is necessary.

Theoretical Considerations in the Use of an Ergmeter; *J. Schroeder* (*Naval Ordnance Laboratory, Silver Spring, Md.*).

Instruments which are directly applicable to measuring the energy of short electric pulses are few in kind. An ergmeter which has been designed is useful in measuring the energy obtained from one-shot pulse generators. This instrument consists essentially of a fluxmeter and a heater-type vacuum tube thermocouple employed as indicating and sensing elements, respectively. The sensing element consists of an evacuated envelope containing both the hot and cold junction of a miniature thermocouple. The hot junction is in thermal but not electrical contact with a low-resistance heater. Connections are made through the envelope to the heater and to the thermocouple by relatively heavy leads. Heater-type vacuum tube thermocouples are used as sensing elements in various commercial instruments calibrated to measure power, voltage, or current of high frequency.¶

A generic ergmeter equation which is derived in this paper shows that the maximum deflection of the fluxmeter is proportional to the heat energy generated by the pulse and dissipated in the heater element. The generic equation is derived on the basis of four assumptions:

(*a*). The difference in temperature of the thermocouple hot junction is equal to the rise in temperature in the heater element which is produced by an electric current i.

(*b*). The energy $Ri^2\Delta t$ delivered to the resistance R in the time Δt is conservatively dissipated by heating the mass m of the heater, and by radiation and conduction.

(*c*). The energy lost by radiation and conduction can be computed in terms of Newton's law of cooling.

(*d*). The electromotive force developed by the thermocouple is proportional to the difference in the temperature of the hot and cold junction. The construction of the vacuum tube thermocouple is such that no error is introduced in measurement of short transients by assuming that the temperature of the cold junction remains constant at ambient temperature.

Specific applications of the generic equation are made to both exponentially decaying and square pulses. It is shown that the proportionality factor for a square pulse of short duration is the same as for an exponentially decaying pulse. It is noted, however, that an increasingly greater error is introduced for pulses of longer periods. As a consequence the ergmeter is not suitable for measuring the energy of long pulses. Furthermore, the ergmeter is also not to be overloaded, for Newton's law of cooling is not valid under this circumstance.

The ergmeter calibration factor is obtained by discharging a standard noninductive capacitor through the heater element. It is considered important that the internal energy losses of the calibration capacitor be either negligible or corrected for. The internal losses of air or good mica capacitors are considered negligible in calibration. For calibration a discharge key with low-energy losses and no chatter should be chosen.

It is suggested that the ergmeter may be employed to obtain a value of the effective series resistance of capacitors. The ergmeter, besides having been used to measure the energy supplied by pulse generators for initiating squibs and detonators, has been used also to measure the energy required to rupture fuse-wires, and the deionization voltage of gaseous discharge tubes.

The Conductivity of Silicon and Germanium as Affected by Chemically Introduced Impurities; *G. L. Pearson* (*Bell Telephone Laboratories, Murray Hill, N. J.*).

Silicon and germanium are semiconductors whose electrical properties are highly dependent upon the amount of impurities present. For example, the intrinsic conductivity of pure silicon at room temperature is 4×10^{-6} (ohm centimeter)$^{-1}$ and the addition of one boron atom for each million

silicon atoms increases this to 0.8 (ohm-centimeter)$^{-1}$, a factor of 2×10^{5}.

Although such impurity concentrations are too weak to be detected by standard chemical analysis, the use of radioactive tracers and the Hall effect has made it possible to make quantitative measurements at impurity concentrations as small as one part in 5×10^{9}.

Silicon and germanium are elements of the fourth group of the periodic table with the same crystal structure as diamonds and they have respectively 5.2×10^{22} and 4.5×10^{22} atoms per cubic centimeter. The addition of impurity elements of the third group such as boron or aluminum give defect or *p*-type conductivity. Elements from the fifth group such as phosphorus, antimony, or arsenic give excess or *n*-type conductivity.

The conductivity at room temperature, where it has been shown that each impurity atom contributes one conduction charge, is given by equation 1 where N is the number of solute atoms per cubic centimeter.

$$\sigma = A + BN \qquad (1)$$

The constants A and B for the various alloys investigated are given in the following table:

Alloy	A	B
Si+B	4×10^{-4}	1.6×10^{-21}
Si+P	4×10^{-4}	4.8×10^{-21}
Ge+Sb	1.7×10^{-4}	4.2×10^{-16}

Equation 1 applies to solute atom concentrations as high as 5×10^{19} per cubic centimeter. At higher concentrations the mobilities are lowered due to increased impurity scattering so that the computed conduction is higher than the measured.

The Bell Computer—Model VI; *E. G. Andrews* (*Bell Telephone Laboratories, New York, N. Y.*).

The Bell Telephone Laboratories has just placed in operation a new digital-type computer at its Murray Hill building. It is called the Bell Computer, model VI,* because it is the sixth type of the seven relay computers designed and built by the Bell Laboratories.

Physically the model VI consists of two principal parts. First is the remote control station at which the computer is operated by the computing staff. Problems are controlled and answers are recorded entirely at this point. The second part comprises the computing equipment consisting of approximately 4,300 relays, 86 cold cathode tubes, and few other miscellaneous types of apparatus employed in telephone switching design.

This computer has been patterned very closely after the model V General Purpose Computer which has been described before.**

Only the features which are new to the model VI will be described herein.

Numbers are introduced into the computer as 3-, 6-, or 10-digit numbers using the so-called floating decimal point. To illustrate, the speed of light is $+1.86\times10^{+5}$; the coefficient of expansion of copper is $+1.68\times10^{-5}$.

Means have been provided to eliminate a substantial part of the arduous work of programming the instructions for solving a problem. This has been accomplished by providing a large number of internal computing programs for frequently used subroutines. In this category are subroutines for finding a trigonometric function of an angle, for obtaining the logarithm of a number, for complex number arithmetic, for computations of impedances for various configurations of inductance, resistance, and capacitance, just to mention a few of the 200 types for which equipment is provided.

Previously it was necessary for the programmer to enumerate each detailed step of these subroutines and furthermore repeat them over and over because these steps occur frequently throughout many of the problems to be handled. But with this added feature, it is now necessary only to denote the number assigned to the routine, such as *A14* or *D36*.

The device used for this purpose is a combination relay and electronic device which is used in the Automatic Message Accounting System in a modern telephone office. As used in telephone switching it consists of a large group of code points corresponding to the location of the call originating equipment of a subscriber. A signal on one of these code points denoting the origination of a call causes the circuit to ascertain and record the subscriber's 4-digit directory number.

As used in the computer the code points correspond to the computing operations in a subroutine. A signal on one of these code points causes the computer routine control circuit to make a record of a type comparable to a 4-digit number which in turn sets into operation the desired computer operation. A subroutine will use 6 to 20 of these steps in succession.

Physically, this equipment in its telephone systems application consists of four rows of ten coils each, thereby making it possible to designate any one of 9,999 numbers. In the computer the equipment also consists of four rows of coils which makes it possible to impart to the control equipment a 4-element instruction such as $A\times BC$ which means that the numbers in the A and B registers are to be multiplied and the result is to be placed in the C register.

A particular instruction is specified by connecting a wire from the code point through a coil in each of the four rows. In the foregoing case the wire would be run through the large opening in the A coil in the first row then through the opening in the "X" coil in the second row, and so on. Such wires are semipermanent for they may be retained in place as long as desired. It is not necessary to solder them to the code points and they therefore are handled easily by the personnel that operates the computer.

A computer operation is initiated by causing a transient discharge from an LRC network to be sent through the wire. The system consisting of the wire behaves like a transformer with the wire acting as a loosely coupled one-turn primary winding and the coil acting as a secondary. The voltage induced into the secondary causes a cold-cathode tube to fire and thereby record the instruction.

In concluding, a reference is made to a pertinent remark made by one of the Bell Laboratories scientists several years ago to the effect that the large-scale computers are like very accurate but very dumb computresses because they require their supervisor to give them a computing program complete in every detail for each new assignment. But this criticism has now lost some of its force because the model VI has this provision of internal routines which eliminates much of the need of specifying every instruction detail for the commonly used subroutines.

Nucleon Bombarded Semiconductors;* *K. Lark-Horovitz* (*Purdue University, Lafayette, Ind.*).

Germanium and silicon have been exposed to bombardment of deuterons and alpha particles from the Purdue cyclotron.[1] These semiconductors and, in addition, selenium, tellurium, and cuprous oxide samples also have been bombarded in the Oak Ridge nuclear reactor with neutrons. The results show that regardless of the nature of the bombarding particles, the following results are obtained: Germanium conducting through positive carriers (*P*-type), so-called "holes" shows a steadily decreasing resistance upon irradiation. On the other hand, germanium conducting by electrons (*N*-type) shows an increase in resistance until a maximum is reached and after this maximum the resistance decreases again. In this range the germanium now is conducting, not by electrons, but by holes, as proved by Hall effect measurements. This indicates that irradiation produces acceptors, which in turn will produce "holes" or *P*-type carriers. Their number is of the order of magnitude of the number of bombarding particles.

This behavior of germanium can be used successfully by bombarding bulk samples of germanium with electron conduction (*N*-type) and producing on the surface of these samples a *P*-type layer which is penetrating only as deep as the range of the particles—either alpha particles or deuterons. The resulting *P-N* boundary acts as a photoconductive layer, as source of a photo electromotive force, and is an "ideal" rectifier. Germanium irradiated in the nuclear reactor turns throughout the whole volume from *N*-type to *P*-type.

On the other hand, silicon, selenium, and cuprous oxide show a steady increase in a resistivity upon bombardment with nucleons. By heat treatment it is possible, in the case of silicon and germanium, where this has been tried successfully, to anneal and reconvert to the original state. In all cases the energy levels introduced by bombardment are higher than the ones introduced by chemical impurities. In the case of silicon, results indicate that these levels lie as high as 0.4 to 0.5 electron volt and seem to contain both donators and acceptors. As a consequence, regardless of whether *N*-type or *P*-type silicon is used, resistivity increases upon bombardment.

It is possible to introduce germanium and silicon crystals as well as cuprous oxide and

* Previous Bell computers have not carried model numbers but numbers that are now assigned to them in retrospect are
Model I—Complex Number Computer
Model II—Relay Interpolator
Model III—Ballistic Computer at Fort Bliss, Tex.
Model IV—Ballistic Computer at Naval Research Laboratories
Model V—General Purpose Computers at Langley Field and Aberdeen

** See: "Mathematical Tables and Other Aids to Computations," Dr. F. L. Alt, January 1948, page 1, and April 1948, page 69, *Bell Laboratories Record*, S. B. Williams, February 1947, page 49.

* This work assisted by a Signal Corps contract.

selenium rectifiers into the nuclear reactor and observe the behavior of the characteristics.[2] In the case of germanium it is found that in agreement with the experiments on bulk samples, in the region of over two volts in the forward direction when the spreading resistance is primarily determining the behavior of the samples, the resistance increases until a maximum is reached and then decreases: the sample has become *P*-type and shows the behavior of a *P*-type rectifier. Below 0.15 volt in the forward direction the resistance decreases as it also does in the backward direction. In this region the resistance is determined by the barrier and the barrier resistance in *N*-type material which is transparent to "holes" becomes lower upon introduction of acceptors.

By using deuteron irradiation of the germanium rectifier, it was possible to show that self-healing effects play a large part in the process. After irradiation the material is converted to *P*-type which, in contact with tungsten, is apparently nonrectifying, but which, in contact with aluminum, showed the behavior of a *P*-type rectifier.

By following the behavior of the germanium rectifier in steps of about 0.05 volt in the forward direction, it is possible to determine the voltage range where primarily the barrier and where the spreading resistance determines the behavior of the rectifier. It is possible in this way to discuss the theoretical aspects of the rectifier properties.

In silicon, cuprous oxide, and selenium, the rectifier behavior follows the behavior of the bulk type—the resistance increases in both directions.

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The Control of the Conductivity of Oxide Semiconductors by the Admixture of Other Oxides; *N. C. Jamison* (*Philips Laboratories Inc., Irvington-on-Hudson, N. Y.*).

Thermally sensitive resistors of the oxide semiconductor type have assumed a position of increasing importance in technology during the last decade. These resistors are characterized by a large negative temperature coefficient of resistance and have specific resistances which lie between those of metals and insulators. Within the last few years two new methods for the control of the conductivity of oxide semiconductors have been developed at the Philips Research Laboratory at Eindhoven, Netherlands, as the result of work done by Verwey, Haayman, and Romeyn.

In the first method the basic material is Fe_3O_4 which has the spinel structure and, for a semiconductor, a very low specific resistance. There is evidence that the reason for the high conductivity of this substance is that both ferrous and ferric ions occur in equivalent lattice sites and only a small amount of energy is necessary to cause the transfer of an electron from a ferrous to a ferric ion. The replacement of some of the iron atoms by an element such as aluminum should cause a large change in the specific resistance. This may be accomplished by sintering a 1:1 mixture of Fe_3O_4 and $FeAl_2O_4$ (also of spinel structure); the resulting semiconductor has a resistivity about 50,000 times that of Fe_3O_4. In general, sintering Fe_3O_4 with a material of spinel structure which has a high resistivity yields a semiconducting material with an intermediate resistivity, the value depending upon the composition of the mixture.

The second method has a wider scope in that the conductivity of a substance such as nickel oxide, which has the simple rock-salt structure, may be greatly increased by the substitution of lithium ions for a fraction of the nickel ions in the lattice. The replacement of a nickel ion (valence two) by a lithium ion (valence one) induces a neighboring nickel ion to assume a valence of three. The presence of divalent and trivalent ions in equivalent lattice sites gives rise to conduction, and the conductivity is a function of the lithium content. Thus by the substitution of elements of suitable valence in the lattice, the conductivities of oxide semiconductors may be adjusted over a wide range.

General Features of Photoconductivity and Photoemission in Semiconductors; *Lloyd P. Smith* (*Cornell University, Ithaca, N. Y.*).

When light of appropriate wave lengths is absorbed in a solid, the absorbed energy manifests itself in several ways: The light energy is transferred to vibrations of the atoms in the solid lattice (the temperature increases); part of the energy is so transferred to the atoms and part is re-radiated as light of longer wave lengths (fluorescence); the light energy in quanta of $h\nu$ is absorbed by electrons in the solid in such a way as to increase the electrical conductivity (photoconductivity); or the light quanta are absorbed by the electrons in such a manner as to eject some of the electrons entirely from the solid, resulting in the external photoelectric effect (photoemission). The general features and certain details of the mechanism involved in the latter two processes, which result in a transduction of light energy into electrical effects in solids, will be discussed briefly.

The ratio $\frac{\Delta\sigma}{\sigma}$ of the change in electrical conductivity $\Delta\sigma$ produced by light absorption and the actual conductivity σ of a solid is very small and generally unimportant for a metallic conductor, appreciable for many semiconductors, and can be very large in the case of normal insulators. From a practical point of view this makes the situation in semiconductors and insulators the most interesting.

Photoconductivity essentially arises from the fact that certain electrons in the solid which normally occupy states in which they are not very free to move through the solid under the action of an applied electric field take up the energy of the light quantum-wise and thereby are raised to states in which they are much more mobile and can respond to a field, thus producing an increase in the electrical conductivity during light absorption. The reason for the large range of values of $\frac{\Delta\sigma}{\sigma}$ for the various types of solids referred to above is that: In metals there are normally an enormous number of mobile electrons so that σ is very large to begin with, and at the same time the quantum efficiency (ratio of the number of electrons rendered mobile per second to the number of incident light quanta per second) is usually small in a metal, thereby making $\Delta\sigma$ small; in semiconductors, the number of normally mobile electrons is very much smaller than in a metal, making σ very much smaller while at the same time the quantum efficiency can be of the order of 100 per cent, making $\Delta\sigma$ much larger than for metals; in the case of insulators $\frac{\Delta\sigma}{\sigma}$ can be almost infinite, since normally there are essentially no mobile electrons and $\Delta\sigma$ may be of the same order of magnitude as for semiconductors. The differences in quantum efficiency can be understood in the main in terms of the conservation of energy and momentum during the absorption process.

The number of electrons rendered mobile per incident quantum in various solids range from values considerably less than unity to well over 5,000, the latter large number is thought to arise from secondary processes.

Many of the same considerations are pertinent to photoemission. Here the number of electrons ejected per incident light quantum range from 1 in 10,000 in pure metals to 1 in 3 for certain semiconductors.

The External Photoelectric Effect as a Tool in Studying Semiconductor Surfaces; *LeRoy Apker* (*The Knolls Research Laboratory General Electric Company, Schenectady, N. Y.*).

The study of photoelectric emission played an important role in the early development of quantum theory shortly after 1900. Later, in the 1930's, it afforded one of the most direct demonstrations of the validity of quantum statistics as applied to the free electrons in metals. It now is entering another stage of development, and is becoming a useful tool for investigating the behavior of electrons at free surfaces of metalloids and semiconductors.

The fundamental method was developed by Millikan in 1915, and Condon later pointed out its value for studying semiconductors. Experimental results, however, have been obtained only in the last few years. The technique involves two main steps. For reference purposes, one first determines the distribution in energy of the photoelectrons ejected from a simple metal by photons having a single energy. This is done by setting up known electric fields to retard the electrons in a phototube having a simple spherical geometry. Provision is made to replace the metal with the semiconductor to be investigated, the two being held in thermal and electrical equilibrium. If this is done without changing other conditions, rather direct information may be obtained about the following characteristics of the semiconductor:

1. The work function, that is, the energy difference between the Fermi level and the top of the surface potential barrier that tends to keep electrons from leaving the material.

2. The width of that part of the forbidden band of energy states that lies between the Fermi level and the densely occupied band below it.

3. Qualitatively, the form of the upper part of this occupied band.

4. Semiquantitatively, the number of energy levels associated with surface states and with impurities near the surface.

Independently, the results may be checked for reliability by varying the energy of the incident photons. Some idea of the uniformity of the surface may be obtained by applying relatively large accelerating fields to investigate the Schottky effect.

In forming a more complete picture of an electronic energy structure, photoelectric data are valuable for comparison with the following information obtained by other well-known methods of investigation: optical absorption spectra, thermionic emission, Hall effect, photovoltaic effects, and electrical conductivity.

Illustrative results will be given for the semimetals As, Sb, and Bi, and the semiconductors Te, amorphous As, and BaO.

A Comparison Between the Schottky Rectifier Theory and Measurements Upon Cuprous Oxide Cells; *Stephen J. Angello* (*Westinghouse Research Laboratories, East Pittsburgh, Pa.*).

Our goal is a theory which will describe the electrical characteristics of dry disk rectifiers in terms of the physical properties of metals and semiconductors. An important contribution to this desideratum has been made by Walter Schottky. In the symposium on "Electrical Properties of Semiconductors and the Transistor," it was our purpose to inform the conferees concerning the kind of numerical agreement which may be expected between the theory and experiments upon cuprous oxide cells.

We have chosen as important properties of the rectifier to be explained by the theory:

1. The relation between contact resistance and d-c bias voltage.
2. The variation of contact capacitance with bias voltage.
3. The temperature dependence of contact resistance at zero voltage.
4. The numerical magnitude of the contact resistance and capacitance at zero voltage.

The theory predicts the correct general shape of the resistance–voltage curve, but in the region of several volts in the reverse direction the predicted magnitude of the resistance is a factor of ten higher than the measured value. The slope of the contact elastance squared versus bias voltage curve should give an estimate of the density of conduction centers in cuprous oxide. The value predicted agrees well with independent data upon bulk cuprous oxide. The theory predicts an exponential increase of contact resistance with increasing reciprocal temperature. This law is well obeyed down to about −10 degree centigrade. The slope of this curve on a semilog plot gives a value of 0.48 volt for the contact potential between copper and cuprous oxide. These data along with other physical constants permit an estimate of contact capacitance and resistance at zero volts. The agreement with experimental values is good.

The failure of the exponential resistance–temperature law is due, at least in part, to a frequency dependence of the parallel resistance-capacitance equivalent circuit given by the theory. (Measurements were made in an impedance bridge using an rms voltage of 5 millivolts at 1,000 cycles per second.) This failure presages the next advance in describing the electrical fine structure of the contact. Inadequacy of the theory is probably due to oversimplification of the contact structure. When this is described in detail by means of frequency measurements, the theory may be modified and improved.

Boundary Layers in Rectifiers;* *H. Y. Fan* (*Purdue University, Lafayette, Ind.*).

Rectification depends on the existence of barrier layers, within which there are variations of potential and concentration of charge carriers. When two different substances are in contact there is potential variation in each of them near the contact. This is caused by the difference in the work functions and the requirement of equalization of thermodynamic potentials of charge carriers in the two bodies. Barrier layers so produced are called natural barriers.

Because of the large concentration of conduction electrons potential variation in metals are confined to a very small distance from the surface, of the order of 10^{-8} centimeter. Such thin layers cannot affect the resistance appreciably. The concentration of conducting charge carriers is much smaller in semiconductors. Potential variations can take place, therefore, over a much larger distance: 10^{-6} centimeter for low resistivity (10^{-2} ohm-centimeter) germanium and silicon, and 10^{-4} centimeter for these materials of high resistivity (10 ohm-centimeter). At a metal semiconductor contact almost all the potential variation required to equalize the thermodynamic potentials takes place in the semiconductor.

For the layer of potential variation to show decisive influence on the resistance the concentration of conducting charge carriers in the layer must be small compared with that in the bulk semiconductor, which means that the potential variation must be in the right direction. This should depend upon the work functions of the bodies in contact. For germanium and silicon no consistant correlation, however, is found between the rectification and the work functions of the metal whiskers. This has been explained by the existence of surface energy states on the semiconductor, which more or less fixes the potential barrier irrespective of the metal in contact.

Besides natural barriers rectification may be obtained by artificial barriers consisting of a thin layer of inherently high resistivity between two different good conducting materials. A typical case is the copper oxide rectifier with a layer of high resistivity oxide between the mother copper and relatively good conducting bulk oxide.

Potential variations at the contact of different substances arise essentially from the equalization of thermodynamic potentials. The thermodynamic potential of a semiconductor depends upon the concentration of impurities. Therefore by varying the concentration of impurities potential barriers can be set up inside a single piece of semiconductor. Rectification of *P-N* barriers in germanium and silicon is such a case. *P-N* barriers are found naturally and also can be produced by nucleon bombardment.

When potential variation is comparable with the forbidden energy gap of the semiconductor one end of the barrier has large electron concentration while the other end acquires large hole concentration. With such barriers electrons can be injected into *P*-type and holes can be injected into *N*-type semiconductors.

*This work assisted by Signal Corps contract.

Noise in Semiconducting Contacts; *P. H. Miller, Jr.* (*University of Pennsylvania, Philadelphia, Pa.*).

Experimental observations on the noise generated in metal semiconductor contacts indicate that, in common with other forms of contact noise, the noise power per unit frequency interval is inversely proportional to frequency over several decades (10^2 to 10^6 cycles per second). This extra noise is for frequencies less than one megacycle large in comparison with Johnson (thermal) and shot (diode) noise. These latter forms of noise exhibit a flat frequency spectrum. The shot noise power is proportional to the current while Johnson noise is independent of the current. The extra noise seems to be more nearly proportional to the square of the current rather than the first power. Experiments have been made at the University of Pennsylvania on the temperature dependence of the extra noise. Such experiments are difficult because of lack of mechanical stability of the contact over a wide temperature range and a theory which suggests whether the current through or the voltage across the contact should be kept constant as the temperature is varied. The observations to date indicate that the temperature variation is not large. At first sight this is a surprising result, for if the modulation of the current is a result of the motion of impurity atoms in the neighborhood of the contact, one might expect the noise to vary in much the same manner as diffusion rates.

Transistors when operating under normal conditions are even noisier than crystal rectifiers and exhibit the same frequency dependence. At 1,000 cycles it is not uncommon to observe noise which is 10^8 times the Johnson noise found in resistance of 10,000 ohms at room temperature.

The theory of the frequency spectrum of noise due to density fluctuations has been extensively investigated. The contact is considered to be composed of a series of atomic planes parallel to the surface and the noise current is assumed to be linear function of the density fluctuations of the current modulating impurity atoms. Let the jump time of an impurity atom be λ, the distance between adjacent parallel planes be a, and the effective thickness of the contact be t. The noise power varies as

$$p \sim 0.5 \text{ for } 0 < p < \frac{1}{\lambda}\left(\frac{a}{t}\right)^2$$

as

$$p \sim 1.5 \text{ for } \frac{1}{\lambda}\left(\frac{a}{t}\right)^2 < p < \frac{1}{\lambda}$$

and as

$$p \sim 2 \text{ for } \frac{1}{\lambda} < p$$

It does not appear possible to obtain from this model a noise spectrum which is inversely proportional to frequency over several decades. In order to obtain any sort of agreement with experiment it is necessary to assume unreasonably small values for the jump time. One is forced to conclude that the current through the contact is not determined by the number of impurity atoms in each atomic layer alone but that some co-operative phenomena is occurring.

The Possible Significance of Transistors in the Power Field; *J. A. Hutcheson (Westinghouse Electric Corporation, East Pittsburgh, Pa.).*

The transistor* is a device which possesses certain characteristics which make it of considerable interest to the electronic engineer in industry. The most outstanding of such characteristics is the fact that no heated cathode is required in its operation.

There are applications of the vacuum tube in industry wherein the existence of a heated cathode within the tube constitutes a drawback in so far as the user of the device is concerned. For example, the vacuum tube is used in applications where reliability is of utmost importance. The finite life of the cathode in the vacuum tube makes it necessary for the user to take unusual steps to be certain that when the tube is called on to operate, it has not failed. Clearly, the application of a device such as a transistor in cases such as this would reduce the amount of attention required in order to assure satisfactory operation.

In other kinds of industrial applications, vacuum tubes are not as satisfactory as could be desired, because they are to a degree sensitive to mechanical shock and vibration. Here again the transistor gives promise of providing adequate performance even though exposed to conditions which make the performance of a vacuum tube unsatisfactory.

At present, transistors become inoperative at frequencies in the order of tens of megacycles. This limitation is not believed to be significant in considering the possible application of transistors in industrial equipment. However, the present transistors can handle powers of only a fraction of a watt. This is a serious limitation as many industrial applications require more substantial amounts of power. However, it is hoped that with time this limitation will be reduced.

It should be borne in mind that the characteristics which favor industrial applications while inherent in the design of transistors, are not yet developed to the point which makes immediate application of this device desirable. Much research and development work is going to be required before the ultimate possibilities of the transistor can be realized. It is to be hoped therefore that those working in the development of this device eventually will solve the problems, the solution of which will make possible many industrial applications of the transistor.

The Basic Optics of Infrared Radiation; *R. C. Lord (Massachusetts Institute of Technology, Cambridge, Mass.).*

Infrared radiation is becoming of increasing usefulness and importance to industry and to the military. The industrial engineer therefore will find it worth-while to have an appreciation of the characteristics of radiation in this part of the spectrum, in addition to some acquaintance with the general techniques for producing and measuring it.

The electromagnetic spectrum in the neighborhood of visible radiation consists of the infrared on the low-frequency side and the ultraviolet on the high-frequency side. The infrared occupies about a dozen octaves between the microwave or radar region and the visible red. On a frequency scale the infrared extends from about one-tenth megamegacycle to 400 megamegacycles. More commonly, wave lengths in microns are used (1,000 microns = 1 millimeter), in terms of which the visible spectrum extends from 0.4 to 0.75 micron and the infrared from 0.75 to 1,000 or more microns. Much of this vast region has been little explored, and our discussions will be limited to the well-known parts from 0.75 up to about 30 microns.

Infrared radiation is copiously emitted by hot solid materials, and these are the usual infrared sources. They emit radiant energy over a wide and continuous range of frequencies, although a large fraction of the radiation is concentrated in the neighborhood of a peak frequency. The peak frequency is proportional to the absolute temperature of the solid radiator. For typical radiators the peak frequency corresponds to these wave lengths: the sun, one-half micron; incandescent lamp, one micron; hot electric iron, four microns; solid body at room temperature, ten microns. The shape of the curve relating radiant energy to wave length is more or less the same for all these radiators, and approaches that of the perfect radiator or so-called "black body."

It will be noted that even a body at room temperature has the peak of its radiation curve at ten microns. This means that it is hard to produce radiation of the longer wave lengths, a fact which accounts for our meagre knowledge of the long-wave infrared between 30 and 1,000 microns.

Because in its generation, propagation, and spectral analysis, infrared resembles visible radiation rather than that of radio or radar frequencies, infrared optical techniques resemble those of conventional optics. However there are certain important differences. The large number of octaves to be covered makes it impracticable to use lens optics, so that concave mirrors are almost universally used for focussing purposes. Ordinary glass is opaque to all but the shortest infrared waves, and therefore other materials are required for windows and prisms. Of these, quartz, fluorite, rock salt, potassium bromide, and silver chloride crystals are the most commonly encountered.

Infrared spectrographs operate as do those for the visible apart from the use of mirrors in place of lenses, and except for the detectors. The transmission of infrared through the atmosphere is hampered in certain spectral regions by water vapor and carbon dioxide. Oxygen, nitrogen, and the rare gases are all completely transparent throughout the infrared. Liquid water, on the other hand, is opaque even in rather thin layers (one millimeter or less) over virtually the entire region.

The mechanism of infrared absorption by matter is usually molecular. The vibrations and rotations of individual molecules, whether in the vapor state or condensed to liquids or solids, have frequencies spanning the infrared region. The resonant interaction of the electromagnetic a-c field of the radiation with these vibrations and rotations leads to characteristic absorption bands in the molecular spectrum. Such bands are highly specific for the nature of the absorbing molecule, and have been called "molecular fingerprints."

Radiation Detectors Applicable to Infrared Investigations; *Aleck R. Dennett (Appley Laboratories, Newport, R. I.).*

This paper is a general discussion of measurements in the infrared region of the electromagnetic spectrum, of the principles upon which these measurements are based, and of certain methods and instruments used in infrared detection and analysis.

Because absorbing materials are somewhat selective, care must be taken in the selection of these absorbers for use in different regions of the spectrum. Only the Golay pneumatic cell, a recent addition to the growing list of thermal detectors, is nonselective throughout the entire infrared spectrum, because it uses an all-metallic film as an absorber.

The several components of the Golay cell are an hermetically sealed chamber, an infrared transmitting window, a radiation absorbing membrane, air or a suitable gas, and a flexible mirror which is the connecting link between the detector and the optical system. The optical system is comprised of a grid ruled on glass (100 lines per inch is satisfactory), a small meniscus lens, condensing lenses, a photo cell exciting lamp, and a photo cell.

The operation of this system is explained as follows: The visible light from the lamp is focussed on the flexible mirror after passing through the line grid. The reflected beam on its return passes through the line grid a second time, through the condensing lenses, and then as nearly one-half as possible is deflected to a photo cell by an angle mirror.

The line grid, which is mounted on an adjustable barrel, is so positioned with respect to the meniscus lens and the flexible mirror, that when the flexible mirror is flat, the upper half of the line grid is reflected back and is imaged slightly out of focus on the lower half of this same line grid which originally formed the image. The adjustment is such that the images of the clear portions of the upper half coincide with the opaque portions of the lower half.

Under these conditions only a small amount of light passes through to the photo cell. As the flexible mirror is made slightly concave or convex in response to variations of the infrared (or visible or ultraviolet) illumination falling on the receiving cell, the image of the upper half of the line grid on the lower half of the line grid blurs or sharpens, as the case may be. The amount of light flux reaching the photo cell increases when the image blurs, and decreases when the image sharpens.

A New Thermionic Infrared Receiver; *E. D. Wilson (Westinghouse Research Laboratories, East Pittsburgh, Pa.).*

The exponential dependence of thermionic current upon temperature of the emitting surface has been known for many years, the relationship being explicit in the familiar Richardson's equation. It is also a fact of common knowledge that cesium-oxide photocathodes are sufficiently thermionic even at room temperature to introduce spurious dark current into circuits designed for measurement of very low values of luminous flux. It is conventional practice to cool photomultiplier tubes in dry ice in order to suppress unwanted thermionic currents from the primary cathode.

* Initiated and developed at the Bell Telephone Laboratories.

Although a device has been suggested* for utilizing such temperature sensitivity, it has not been exploited in engineering practice. Because recent years have witnessed a greatly heightened interest in competitive receivers for infrared radiation, it has been thought worth-while to examine the elementary functioning of a thermionic surface as a detector of radiant energy in the region of the spectrum beyond the threshold of photoelectric emission.

First of all, it is a straightforward procedure to operate mathematically upon Richardson's equation and compute the percentage change in current as a function of temperature and take this as a measure of the temperature coefficient of the device regarded as a variable impedance. Using parameters published by Koller,[1] it can be shown that the coefficient is about 20 per cent per degree at room temperature and increases very rapidly at lower temperatures. This compares favorably with the highest values published for other devices.

Of great practical significance in the evaluation of a detector is the ratio of signal to noise. By use of conventional expressions for the shot effect in thermionic emission and for the rise in temperature of a thin target exposed to radiant energy, it turns out, contrary to the usual result, that signal-to-noise ratio actually increases with temperature.

At 400 degrees Kelvin (a feasible operating temperature), the equation indicates that one should be able to detect a minimum signal of 10^{-9} watt for unit bandwidth of the amplifier.

This preliminary analysis seems promising enough to warrant further investigation, particularly in view of the fact that the characteristics of the device are essentially unique.

REFERENCE

1. **L. R. Koller.** *Physical Review* (New York, N. Y.), volume 33, 1929, page 1082A.

Industrial Applications of Infrared Spectroscopy; *Van Zandt Williams (The Perkin-Elmer Corporation, Glenbrook, Conn.).*

The application of infrared spectroscopy in industry has been very recent and very widespread. Although the field has been known for 150 years, it was not appreciated by industrial concerns until 1935–40. However, the war needs of rapid tools for industrial control, analysis, and research provided the impetus for introduction of reliable commercial spectrometers, which have enabled the development in the field.

The uses of industry are primarily the identification and qualitative comparison of organic materials, the qualitative analysis of unknown compounds, and rapid accurate quantitative analyses of organic mixtures. Examples of all three types are numerous, that is, checking the identity of synthetic and natural materials such as folic acid and penicillin, the classic work on the structure study of penicillin which suggested the lactam ring, the hydrocarbon analyses, penicillin assays, determination of water in freon, and so forth.

The foregoing applications have been primarily those of research or control laboratories. At the moment a much greater industrial application, that of direct process control, is beginning. The potential power of this application is the unique ability of infrared methods to measure selectively one component in a process stream. This means that, as the instrumentation develops, processes can be controlled by an instantaneous and continuous measure of the primary variable of concentration, instead of by secondary variables as temperature, pressure, and flow rate. For this purpose the field will see growing use of such instruments as automatic cycling spectrometers, nondispersion analysers, and infrared filter photometers.

* United States Patent 2,144,519.

Subcommittee Report on Electric Equipment for Paper Mill Winders; *C. D. Beck (General Electric Company, Schenectady, N. Y.).*

Paper mill winders rewind the parent rolls from the paper machines, supercalenders, coaters, and so on, into uniformly hard rolls with even edges which will permit smooth and rapid rewinding on subsequent processing machines. The winder itself consists of two drums which rewind the roll by driving on its surface. A separate unwinding stand is provided for the parent roll to be rewound. The winding drums are driven and the unwinding stand is equipped with a brake for applying back tension on the sheet.

Winder drives may be classified as "mechanical tension" or "regenerative tension" and are distinguished by the type of braking used on the unwinding stand. Regardless of the type of braking employed, the operating requirements of the winder drive remain and are

1. Smooth, rapid acceleration and deceleration, readily controlled.
2. A low bottom speed for threading, a soft start, and usually provision for jog operation.
3. For some winders, means must be provided for adjusting the driving effort of each of the winding drums.

Where moderate paper processing speeds are used the following types of mechanical tension drives are suitable and have found extensive use:

1. Wound rotor induction motor drive.
2. D-c constant potential drive.
3. Mechanical clutch drive.
4. Adjustable speed (eddy current) clutch drive.
5. A-c adjustable speed (brush shifting) motor drive.

For high-speed winders where the operating requirements are very exacting, the d-c adjustable-voltage (Ward-Leonard) drive has become the accepted standard of the industry. The outstanding features of this type of drive are a low thread speed and controlled acceleration and deceleration. Also, double motors can be used, one for driving each winder drum to provide additional control of the hardness or softness of the rewound roll, when required.

Regenerative tension drives employ a braking generator on the unwinding stand. An adjustable voltage drive always is used on the winder drums. The braking generator is controlled to hold essentially constant sheet tension between the parent roll and the winder under all conditions of operation including, acceleration, deceleration, and as the parent roll size decreases. With this type of arrangement the braking energy from the sheet tension is not lost but is returned to the winder motor or motors.

High-Temperature Ceramic Insulations; *Hans Thurnauer (American Lava Corporation, Chattanooga, Tenn.).*

Electric heating devices are dependent upon two components, electric resistors and insulators. Above 400 degrees Fahrenheit, only ceramic, inorganic insulators are satisfactory.

Resistance to heat is the most important requirement for high-temperature insulation and a study of melting points of refractory oxides and combinations of such oxides reveals their usefulness at high temperatures.

Another factor which has to be considered is thermal endurance or resistance to thermal shock. This comprises a number of physical properties, which determine the resistance against sudden or frequent temperature changes. The empirical formula of Winkelmann and Schott, which evaluates the shock resistance of glass, is applicable to ceramic materials but has to be modified to take into consideration the heterogeneous structure of a ceramic material. Some of the properties which account for good thermal shock characteristics in a material can be varied over wide ranges, whereas others are not easily changed. Low coefficient of thermal expansion is the most important factor affecting thermal endurance and this property can be varied over wide limits by selecting suitable oxide combinations and crystalline phases. Low density is another requirement for good thermal endurance, but usually accompanied by low mechanical strength and high porosity.

The dielectric properties of ceramics at elevated temperatures are effected by ionic conduction. It is essential that the alkali content of a ceramic body be kept at a minimum in order to reduce ionic conduction and to obtain high resistivity at elevated temperatures.

The usefulness of a ceramic material as an insulator at elevated temperature is evaluated by its *Te*-value, which is that temperature in degree centigrade at which the resistivity of the material is one megohm. Consideration also has to be given to the dielectric strength and in some cases to the dielectric loss factor of the insulating material.

The chief manufacturing processes used for forming high-temperature ceramic insulation are molding in a plastic state, extruding, dry pressing, casting, machining either in the semidry, dry, or fired state. Combinations of these processes are possible.

The designer of electric heating equipment should acquaint himself with these processes to understand possibilities and limitations.

Some Problems in the Measurement of Low-Intensity Fields at Ultrahigh Frequencies; *AIEE Subcommittee on Radiation Measurements Above 200 Megacycles (Prepared by C. W. Frick, General Electric Company, Schenectady, N. Y.).*

In 1947 some problems were encountered in the measurement of radio fields at frequencies of the order of 1,000 to 3,000 megacycles. These problems were associated with new developments such as high-frequency cooking and microwave therapy, which applications might cause interference under some conditions with communications in the same frequency range. Ability to make definite measurements is an important element in the successful handling of such

interference problems. However, measurement experience at such frequencies was limited to transmission lines, wave guides, and radio beams. Little had been done with the measurement of low-intensity non-directed fields in this frequency range.

The AIEE Subcommittee on Electronic Heating took steps to organize a technical group to work on this subject. The group is now organized as a subcommittee of the Electric Heating Committee.

The subcommittee began with a general review of the measurement situation. Basically, it appeared that the same methods that had been used up to 200 megacycles might be extended up to 2,500 megacycles and possibly to 7,500 megacycles. After further experience, work could be undertaken at higher frequencies up to say 30,000 megacycles.

The proposed high-frequency measurement method differs somewhat from the methods commonly employed at standard broadcast frequencies. In the latter case a rod antenna of known effective height often is used with an appropriate indicating instrument such as a radio receiver which is calibrated on a suitable "dummy antenna." Calibrated loop antennas are employed also. At higher frequencies, such as short-wave broadcast and television frequencies, dipole antennas are employed. They can be used at least up to 2,000 megacycles when proper precautions are taken such as correct matching between the antenna and the receiver, and correct matching between the receiver and the calibrating signal generator. Instead of using effective antenna height, effective antenna area may be employed since this concept is applicable to reflectors, horns, and other pickup devices also.

A survey of existing equipment was made. It showed that signal generators are available commercially up to at least 4,000 megacycles. Receivers have been built for frequencies as high as 6,000 megacycles, but they are usually components of some other equipment. The next matter considered was design details of antennas or pickup elements, and a paper was sponsored on this subject.

Conference on Mathematics, Introduction; *Michel G. Malti (Cornell University, Ithaca, N. Y.).*

This conference dealt with classical, operational, and transform methods of the analysis of circuits in the transient state. Many of the fundamental concepts of the subject are more than a century old. Its applications to electrical engineering are relatively recent however. There exists, moreover, some confusion in the minds of engineers as to the relative merits and demerits of the three methods, as to their restrictions, their generalizations, their application to various problems in electrical engineering, and their co-ordination.

It is well perhaps to make some general statements which might clarify the atmosphere and help co-ordinate the papers presented in this conference.

1. We can safely assert that any problem that can be worked out by operational methods also can be solved by the classical or transform methods.

2. The choice of method depends on:

(a). The problem involved.

(b). The familiarity of the person with one method of solution as against other methods.

3. The operational method, developed by Heaviside, applies only to circuits leading to ordinary linear differential equation with zero initial conditions. Hence his method is highly restricted. It also involves assumptions regarding the algebra of operators which cannot be justified. Heaviside realized this. Being however a better physicist than a mathematician, his methods and proofs were sometimes wrong but his conclusions were always right.

4. Heaviside did not study the literature of his day to ascertain whether his ideas had been anticipated. Had he done so he would have found that Cauchy had developed an elegant method, very similar to his, which neither suffered from the restrictions imposed on Heavisides' method nor from the lack of mathematical rigor which characterized Heaviside's work.

5. It is well for us to remember that in spite of the shortcomings of Heaviside's work he can be credited with popularizing the use of differential equations in engineering. In his day differential equations were as strange to engineers as were complex numbers in Steinmetz and Bedell's days. Thanks to him and to Professor Julius Berg, his missionary in the United States, the use of differential equations became more popular until today we can hold a conference on the review and co-ordination of the methods of solving differential equations.

Temperature Measurement for Infrared Heating Processes; *W. F. Hickes (The Foxboro Company, Foxboro, Mass.).*

Advancements in the design and operation of infrared ovens, specifically paint drying ovens, have created a demand for means for measurement of product temperatures. Of the various methods proposed, that is, radiation, work contacting thermometers, traveling thermocouples, and traveling resistance thermometer bulbs, the latter appears best adapted and has been used successfully for four years.

The equipment used in this work consists of resistance thermometer elements of the "stick-on" type attached to representative surfaces on a work sample and connected by trailing cables to a Dynalog temperature recorder (electronic-type resistance thermometer). The elements themselves are $1^1/_2$ inches by 1/2 inch by 0.005 inch and usually are attached to the work by masking tape.

A typical rise of such equipment would be in "tuning up" a new oven. Stick-on elements are attached at representative points on a sample of the work. For tall work, one would be at the top, one at the bottom. Or, one might be on a thin section, another on a thick section. The work is then painted and passed through the oven. The recording thermometer record shows the complete time temperature curve for each point selected.

Based on the record of the first run, lamping may be rearranged and air circulation adjusted repeating the testing and adjusting until the desired time–temperature curve is obtained. The resulting record shows equipment manufacturer, user, and paint supplier exactly what the oven is doing and eliminates divided responsibility in case of poor performance of the product.

Electrode-Type Steam Boilers and Water Heaters; *S. A. Williams (Bastian and Allen, Ltd., London, England).*

Electrode steam and hot water boilers generate heat due to the passage of an alternating electric current through the water itself, obviating transfer through metallic walls, and a fully variable heat input is obtained without operating heavy current-carrying switchgear. Another advantage over metallic resistance types is that much greater heating capacity can be provided per cubic foot of boiler shell.

No disintegration of water to its component gases is evident with frequencies of 25 cycles and above, and very long life of electrodes is obtained by using cast metals and restricted current densities and length of path through the water. Conductivity of normal water supplies is generally between 300 and 700 ohms per inch cube at 100 degrees Fahrenheit and can be increased to the required value by the addition of salts such as sodium carbonate. A more highly conductive water is advantageous in that there is less change of the ohmic resistance with change of temperature.

With 3-phase power supplies the electrodes and water give a combination of star and delta loading and there will be a definite neutral point formed in the water.

In general, electrode steam boilers have their load controlled by variation of the water level, which alters the area of the electrode immersed. This is accomplished by delivering more water from the feed pump than the normal evaporation and discharging any surplus water by an electrically controlled valve back to a feed tank.

With hot water boilers load control is accomplished by adjustable insulating sleeves. Screening the electrodes and movement of the shields can be manual for small boilers, but is more usually power-operated by electric motor or hydraulic cylinder for larger units. The actual position of the shields is adjusted to provide the maximum kilowatt load or such lesser load as is required to meet the temperature conditions for the system.

Standard boiler units for up to 660 volts three phase are built from 30 kw to 1,000 kw and this range is covered by five or six standard sized units.

Scale formation must be studied, as with both steam and hot water units it results in reduction of the available area of the electrodes, and eventually in a reduced maximum loading of the boiler. With the steam boilers the use of condensate obviates scale and with a mixture of hard water and condensate descaling may be required two or three times a year. With hard water and no condensate, some method of softening should be provided. With hot water boilers it is essential to arrange the system so that the water is recirculated and if there is a large water capacity in the heating system it is advantageous to soften the water initially.

Special regulations in various countries cover the grounding of the neutral point of the system at the boiler and any out-of-balance current will return by ground or preferably by the neutral conductor if this is brought to the shell of the boiler. Protection against excessive out-of-balance current can be provided, but usually the only safety requirement is a potential trip connected between the boiler shell and the immediate ground.

INSTITUTE ACTIVITIES

Open Doors

*By Everett S. Lee, President, 1948–49**

As your President, I have had a lovely year. I have been privileged to be with the members often, as I have had the outstanding pleasure to visit 50 of our 84 Sections and 7 of our 42 Subsections, covering our 10 Districts, and have had the genuine enjoyment of attending the four General Meetings and the three District Meetings of our Institute held in the past year, which have carried forward the strength of our Institute into the year to come and through which I have had some contact with all of the Sections. I have seen the youth of our profession in 50 of our 129 Student Branches and in our General and District Meetings where I have had some contact with practically every one of our Student Branches, and I can assure you of the continuance of electrical engineering achievement as these young men enter the profession, undergirded by the contributions to their engineering life by the teachers in the engineering schools of our land and by our Student Branch Counsellors who have brought to them a knowledge of our Institute so that they will continue their future engineering lives with us.

VISITS TO INDUSTRY

As Institute president, I have been accorded an "open sesame" to the industrial power of our land, and everywhere there has been the engineer. I have seen telephones in the making in buildings great and small, and there has been the electrical engineer to provide for us the facility that the voice of each of us can be heard round the world, or selectively to speak in a moment to any one or two or three of millions, a marvel of electrical engineering achievement. In a television receiver factory I saw unprecedented output which is so characteristic of our country whenever a new and popular industry is in the process of development.

I have been in the newest of electric power plants where the engineer continually has opened new doors to increased efficiency of performance and operation to conserve resources, and to furnish electric power at the closing of a switch, instantly and at any moment, to make the wonders of electricity available to all of our people.

I have been in the most modern of steel mills where the hot strip and the cold strip are driven through the gigantic mills by the motors of the electrical engineer. The products of steel come so completely into our lives; one enormous factory alone produced steel exclusively for the tin cans which carry food into the homes of the people of the world. I thought, as I saw the wonders of the engineer in that great factory, would that the housewife who opens the can could have an appreciation of the engineering achievement which produced it, and of the engineering processes which went into the contents.

I have seen the world's heaviest locomotive, an electric locomotive, which was shown to me by the electrical engineer who dreamed of it, whose vision had come into being. As he opened a door here to show me a new and exclusive feature, a door there to show me the latest of design, I realized I was in the presence of the engineer who opens the doors to new accomplishments, to new advances, and to new products. If it were not for the engineer, the doors would not be opened. That is the mission of the engineer. It is his contribution to what we have today; it is his to contribute that we advance from where we are today to even a happier life for those that are to come.

I have seen a paper mill with its product even as fine linen, and the engineer said, laying a piece of the wonderful product across his hand, "Mr. Lee, that is the finest piece of paper made anywhere in the world." I praised him for his complete pride in his product, and I find this pride in the engineer everywhere. It is good that this is so for it attests to the hours of patient care, toil, and thought that have gone into the product to make it the best, and to the superlative engineering tools provided by the leaders of industry in order that these outstanding products may be had by all of our people.

Everett S. Lee

Every material thing we have has behind it a romance of engineering and industrial achievement. That this is not generally recognized is a door for the engineer to open; I am glad for the recognition of this opportunity by the AIEE Committee on Public Relations and for the publicity kit being furnished to our Sections for their use. Too many of our profession do not see the profession in its greatness for they do not recognize its great strength nor its outstanding contributions. I find in talking with the so-called "man on the street" that he regards scientists and engineers as men apart who can do anything, and, given time and money, they can. He reveres them for their outstanding contributions, and he applauds them.

But too often I have found that the engineers look upon an outstanding contribution as just another accomplishment and immediately move on to another, without revealing the greatness of the service rendered. I deplore the derogatory statements of the position of the engineer made by some engineers themselves. The correction of this position is a door to be opened by the engineers as individuals, in their local groups, and in their state and national groups. It is of fundamental importance that this be done.

THE ENGINEER AS AN INDIVIDUAL

One of the greatest delights of my year as president has been to learn of the services being rendered by engineers as individuals. I spoke to a Kiwanis Club and the president of the club was an engineer. I visited another Kiwanis Club and the man elected that day to the presidency of his club was an engineer. I attended a Chamber of Commerce meeting in a small industrial city and there were a goodly number of member engineers present. In one large city I found a beautiful building for an engineers' club. When I asked the engineer who showed it to me where it came from, he said, "Oh, we got it." Yet, later I learned that it meant the raising of more than a hundred thousand dollars to "get it," and that he was the engineer who spark-plugged it all. Everywhere I have been I have found spark plugs; engineers who are doing things beyond their engineering lives, engineers who are happy in their profession for the privileges of service which have been offered by technical achievement to open new doors of engineering accomplishments and in working generally with their fellowmen to open new doors to social betterment. This the engineer is so well equipped to do with his ability, his logical thinking, and his reduction of many factors to fundamentals,

(*Continued on page 694*)

*An address at the Annual Meeting held on June 22, during the Summer General Meeting, Swampscott, Mass., June 20–24, 1949.

Engineering Organization

*By James F. Fairman, President, 1949–50**

I suppose that each of the 61 men who have been introduced at the annual meetings as president-elect have experienced emotions similar to mine. They have been proud of this organization—of what it has accomplished and of what it represents. They have appreciated what it has meant to them and welcomed the larger opportunity for service which the office of president afforded them. They recognized that the members have bestowed on them the greatest honor which is theirs to give. Having served on the Board of Directors, they realized there is some work, as well as honor, involved in being president. They may have suspected that one year is all too short a time to accomplish even a fraction of the things they would like to do, but they accepted that as a challenge. They were optimistic and a little humble. They promised to do their best, they asked for your help, and they thanked you—all of which I do.

Probably my predecessors received, as I already have, suggestions from members as to what ought to be done during their term. I am sure they welcomed those suggestions as I do. Some of the suggestions are most flattering in their implications. One of my good friends said he was confident my term would be "the year of decision." That made him vulnerable, and before he knew what had happened he had accepted the job of studying some of the problems and preparing recommendations on which the Board of Directors could make decisions. Lest his experience deter anyone from offering suggestions, may I assure you that all standing committee chairmen have been appointed. The hard jobs are all filled. Of course, for good cause or on sufficient provocation, your president always can appoint special committees.

From a number of members has come the suggestion that the Institute should promote vigorously the project initiated four years ago—known to some as the four plans, *A* to *D*, inclusive, or perhaps better known in a later stage as the Hull proposal for a constitutional convention to be called for the purpose of seeking to devise some form of over-all organization for the engineering profession, or at least to propose some scheme for greater unity of action in matters of common interest. Having been associated with this project from its inception and having done some of the pushing to keep it moving, I can assure you that I intend to keep on pushing.

Projects of this kind progress slowly. We have been at it only four years. We in the Institute used the first two years to study the problem, to sample membership opinion, to draw conclusions and report them. Since the next step involved negotiation with other engineering societies and presumably similar studies by them, we submitted our findings to Engineers Joint Council with the recommendation that that body carry on the project on behalf of the five societies there represented. Engineers Joint Council appointed a committee on unity to study the AIEE report and any other suggestions, and during his term of office President Hull stumped the country in support of the proposal for a meeting of representatives of any interested national engineering societies to consider what might be done. I am happy to inform you that the Committee on Unity has made its report, Engineers Joint Council has adopted it and just last week issued an invitation to 15 engineering societies to appoint representatives to an exploratory conference to be held in October.

If this conference is held, as I hope and believe it will be, a good beginning will have been made—but only a beginning. The real hard work lies ahead. If we realize this at the outset, we shall not be so easily discouraged when the going gets tough, as it will. Neither will we become impatient with the rate of progress if we will recall that it took four years to get started. What we are trying to bring about is not new. It has been tried a number of times in different ways with varying degrees of initial enthusiasm. Whether or not we will do better this time remains to be seen.

The only decision the Institute possibly can make in respect to this matter during the coming year would be a reaffirmation of its previous position when it offered the results of its studies to Engineers Joint Council. This decision would require prompt acceptance of the invitation, appointment of a representative, and submission of the same studies as an item for the consideration of the exploratory conference.

Inasmuch as this conference is only exploratory, I hope that the representatives of the participating societies will not be encumbered by instructions from their respective organizations or inhibited by their own caution. I hope they will feel that they have the utmost freedom thoroughly to explore the problem and to recommend the next steps which might be taken toward its solution. I hope that no one will insist on any conditions as necessary to his initial or continuing participation in the conference. I hope that the representatives will be chosen for their tact, courtesy, and patience, as well as for their interest in the problem. I hope they will not be influenced by the relative antiquity or size of their respective societies. I hope that the representatives of the older organizations will keep in mind the fact that the present fragmentation of the engineering profession which gives rise to the problem is due in part to what those groups did or failed to do in their youth. I hope that they will work in an atmosphere of confidence and good will. I hope we will give our representatives a fair chance to do their job by withholding our criticism until they have made their report. Finally, I hope that a lot of people will share my hopes and that each will do what he can to insure their realization.

James F. Fairman

Although we in the Institute cannot hope to arrive at any decision on the broad problem of the over-all organization or greater unity of the engineering profession during the coming year, we can and we should, without prejudice to the ultimate answer, arrive at a decision as to the policy which the Institute should follow in the interim as a guide to its own activities.

Having participated constructively in the deliberations of the Board of Directors and certain of the general committees for nearly four years, and being deeply concerned about the problems with which the Directors were confronted at nearly every meeting and the difficulty of making consistent decisions without a clear-cut statement of policy as a guide, Director Walter C. Smith introduced a resolution at the last meeting of the Board on April 20 as his contribution to reaching a decision on fundamental policy. As individual members of the Institute, each Board member knew how he would vote on the resolution, but as Board members no one of us felt that he had sufficient understanding of the attitude of the membership-at-large to warrant immediate action on the matter. In order to obtain some idea of the views of the membership, it was agreed to refer the resolution to a special committee whose assignment would be first, to bring the resolution to the attention of the Sections for initial discussion at the Section Delegates Meeting at the Summer General Meeting and for further study by the Sections in the fall; and second, to obtain, summarize, and report to the Board of Directors at the 1950 Winter General Meeting the results of this sampling of membership opinion. If this informal procedure returns a reasonably clear verdict, the Directors can adopt with more confidence some appropriate statement of policy for the guidance of Institute activities in the immediate future. If I may express another hope, it would be that each Section will give serious consideration to the problem and co-operate with the special committee by making the returns promptly and in the manner requested.

Whether or not this becomes a "year of decision" depends on you as well as on me. I am sure I may count on your assistance.

*An address in response to receipt of President's badge at the Annual Meeting held on June 22, during the Summer General Meeting, Swampscott, Mass., June 20–24, 1949.

(*Continued from page 692*)

if he will but recognize his ability of application in the general field and will use it. Besides, in the general field the engineer can include a little time looking after himself for this he should do also.

I wish I could tell you more of the engineers who have told me of their work on school boards, in civic groups, and on the street railway commission. Two of our members are mayors of their communities, several are on governing boards of cities and towns, a large number are in Boy Scout work, in the Young Men's Christian Association, and in the churches. I know we all thrill with the known contributions of two of our best known members, Vannevar Bush and Karl Compton, Fellows of our Institute, who are giving outstanding service to our country. We cannot all be Vannevar Bushs and Karl Comptons, of course, but I have found this year that there are many more engineers individually giving of their time to living with their fellowmen in their work beyond the technical than I ever had visualized before, and I have been in a position to know something of it. But the engineer does not shout his service from the housetop, thus even his fellow engineers do not realize nor recognize the high regard of the engineer from these contributions made in his living with the doctors, lawyers, merchants, bankers, school teachers, farmers, and those in government who live in their communities.

To those engineers who have not had the personal happiness of these relations, there is a door for them to open which not only will bring satisfaction to themselves, but will bring that recognition of the profession which they visualize should be.

This year I have been privileged to visit the great research laboratories of the industries of our land, in our schools, and of our government. Here the scientists are bringing forth new knowledge for the engineer to have and to use as he brings forth new products and improves present products. Here again is our great strength in this great country of ours that the scientist is ever searching for new knowledge beyond the present for the engineer to have and to use. Here is where new doors are being opened continually and where the engineer has ever-expanding opportunities to broaden the fields which are open to him for advancement. It is his responsibility to follow these opportunities.

To this our Institute has responded with new technical committees and with a new technical committee organization to allow for increased participation along these expanding avenues. As President, I have had to view these from a little distance, but the increasing participation in the Sections, and the holding of technical conferences in the Section territories which this year have been so outstandingly successful, surely has provided for the advancement of our technical activities which are our great strength. Our technical paper contributions have increased. When you receive your issue of *Electrical Engineering* you can know that it goes to more than 50,000 other electrical engineers and students, and into libraries, to be a great powerhouse of new electrical engineering advancement read round the world. Our *Transactions*, recording the history of electrical engineering achievement since 1884, are another of our great strengths to education for scientific and electrical engineering advancement throughout all of these years.

OUR STUDENT MEMBERS

It has been my special privilege this year to have been with the Students. They have been in our every meeting—and the endeavors of the members of our Sections working together with the Students in the Student Branches is everywhere most substantial and mutually helpful. As there is the opportunity, I hope that this may ever increase, for in the youth of our profession is another of our great strengths; it is the young man who, in the eagerness of his youth, opens new doors and the older men must be there to aid him in their further progression.

At Spokane, Wash., the Students had their meeting and they were called to order at 9:30 a.m. by their Student Chairman who said, "Fellow Students, it is now 9:30 and the meeting will come to order. Now each of you to speak has his time assignment and I don't want anyone to run over his time as I want to close the meeting at 12:00 noon sharp so that I can play golf this afternoon." I applauded and I said that he was a young man after my own heart; he did his engineering in the morning and played golf in the afternoon and that is the formula for engineering success. Then I said to the group, "Remember, boys, the world needs engineers for engineering, and the world needs electrical engineers for electrical engineering, and don't you ever forget it. Learn to be the best engineer you can be, and the best electrical engineer you can be. Study hard, work hard, and do it without ceasing; but, don't give all of your time exclusively to your engineering, give 5 per cent, or 10 per cent, or 15 per cent, whatever you find you can, to living with your fellowmen. Go to the ball games be they baseball or football, and play them as you can, whether they be golf or tennis or handball.

"Spend some time with your fellow men in your community; come to know the doctors, the bankers, the lawyers, the merchants, the school teachers, those in government, and they to know you, and you will find in your engineering life and your general life those satisfactions which come from service in each, and which will bring you a happiness which you will have always.

"Yes, there will be difficulties and heartaches, they will be in both your engineering life and your civic life; but as long as the victories are greater than the defeats, the credits more than the debits, you will find great satisfaction. I am sure it will be substantial."

That is the message which I have brought to our Student members as I have been privileged to be with them in their Student Branches and in our General and District Meetings. As I have told this to our Section members, I have received comments of approval. There are doors for our Students to open, and as they move forward into their engineering life it will be the doors they open that will bring to them and to their fellowmen the life satisfactions which are the privilege of the engineer.

THE POSITION OF THE ENGINEER

While at Spokane we were asked to tell of the position of the engineer in life, and after recalling to that great audience in the Spokane Chamber of Commerce that in back of every project in their great inland empire stood the engineer, we said: "From the great research laboratories of industry, from our schools, and from our government, comes the new knowledge, and the engineer listens for this new knowledge which he molds into products for the people to have and to use. Then there are the great industrial leaders of our land who have led us to bring forth large companies, medium-sized companies, and many many small companies which are our great industrial strength in this country to progress the products of the engineer. There are the workers in the shops who with the proficiency of their hand and eye operate the machines to turn out the products of the engineers for the people to have and to use. There are the salesmen, the peddlers we call them, who separate the dollars from the people for the products, and the products thus finally get to the people for their use and enjoyment. This is a long and a noble procession. Note where the engineer stands; he stands in the forefront of the procession, and if he does not open the door to new products, there will be no new products. Every material thing we have comes from the engineer, who can hold his head high for he stands in the forefront of the procession."

There is another group of people entwined in this procession. There are the doctors who keep us in good health; the lawyers who keep us in line and keep us out of jail; the bankers who provide the wherewithall to give us a start and to help in keeping us going; the ministers who guide us in paths of righteousness; and the school teachers who teach us all and bring understanding and wisdom everywhere to the youth entering the procession to keep the whole procession continuously supplied. The result in this great country of ours is what we have all done together. Note the position of the engineer in the forefront of the procession. His independence is great; he opens new doors; his dependence is great that the procession through the open door is for great good.

This is the 65th year of our Institute. For 65 years we have provided the electrical engineers of our land with the privileges of meeting together that each one could tell the other of the new advances in electricity which has been his contribution. The sum total of these contributions has been of outstanding magnitude, for the electrical engineer has opened new doors and all of industry working together has progressed electricity into every available avenue for the use and enjoyment of people everywhere. Words never can express adequately all that this means, for visualize it as you will and make it in your visualization as great as you will, it always will be greater than you can visualize. The history of this advance is recorded in our *Transactions* for these 65 years. This has been our contribution through our Institute.

Thus in this accomplishment through our Institute we have defined the electrical engineering profession. It is there for the world to see. It is there because we have built it, built it with our hands, our heads, and our hearts. Every electrical engineer can hold his head high because of this achievement.

Final Arrangements Completed for 1949 Pacific General Meeting

The AIEE Pacific General Meeting will be held this year in San Francisco, Calif., from August 23 through August 26, with headquarters at the Fairmont Hotel. A comprehensive program of technical meetings, inspection trips, and social functions has been planned.

The AIEE is fortunate in its choice of San Francisco as the 1949 meeting site, for this is the Centennial year, marking the 100th anniversary of the great California gold rush, and San Francisco will be the center of several celebrations and special events planned to commemorate the history of 100 years ago. Members planning to attend the Pacific General Meeting will find it worth-while to include a vacation with their visit to San Francisco.

The meeting will be opened by the Chairman, George C. Tenney, at 10:00 a.m., August 23. A general session with W. C. Mullendore as speaker will follow the welcoming remarks by San Francisco Section Chairman, T. C. MacFarland.

REGISTRATION

Members should register in advance by filling in and mailing the advance registration card sent with the mailed announcement. Advance registration will permit arrangements to be completed before arrival and will save time at the registration desk.

A registration fee of $3 for members and $5 for nonmembers has been established, in accordance with the policy set up by the Board of Directors. These fees will be collected at the hotel registration desk, and so no remittance should be enclosed. Plans for attending inspection trips, as well as desires for hotel accommodations, should be indicated on the registration card.

The AIEE registration desk in the main lobby of the Fairmont Hotel will be open for preliminary registration between 7:30 and 9:30 p.m. on Monday, August 22.

HOTELS

Rooms have been set aside at the Fairmont, the headquarters hotel, and at two others, the Mark Hopkins Hotel and the Sir Francis Drake Hotel, both within reasonable distance.

The Fairmont Hotel is atop Nob Hill in the city of San Francisco, about eight blocks from the center of the theater and shopping district. The Mark Hopkins Hotel is directly across California Street from the Fairmont, while the Sir Francis Drake Hotel is approximately halfway between the headquarters hotel and the shopping district.

Hotel reservations should be made by using the advance registration card sent with the mailed announcement.

Room rates are as follows:

Fairmont:

Singles	$7.00, 9.00, and 12.00
Double or twins	8.00, 10.00, and 13.00
Suites	22.00 to 35.00

Mark Hopkins:

Singles	7.00, 8.00, 9.00, and 10.00
Doubles or twins	10.00, 11.00, 12.00, and 13.00
Suites	20.00, 25.00, and 30.00
Double bedroom suites	Add 12.00

Sir Francis Drake:

Singles	6.00, 7.00, and 8.00
Doubles	8.00, 9.00, and 10.00
Twins	9.00, 10.00, and 11.00

Arrangements also have been made to accommodate up to 100 male students and male faculty members at the University of California International House, 2299 Piedmont Avenue, Berkeley, Calif. The accommodations will provide single and double rooms with detached bath at $2 per person per day.

The International House is an attractive modern establishment immediately adjacent to the University of California. A transbay train or bus trip of about one hour is required from the headquarters hotel to the International House.

SOCIAL FUNCTIONS

The social program will include a banquet, a general luncheon, and a number of events especially planned for the ladies. Since space at all functions will be limited, it is desirable that advance reservations be made. Reservations will be made on a first come–first served basis.

The reservation card enclosed with the mailed announcement should be used and enclosed with remittance for tickets. Tickets for all events will be available at the registration desk.

BANQUET

An informal banquet with entertainment will be held at 7:30 p.m. on Thursday, August 25, in the Gold Room of the Fairmont Hotel. An excellent dinner will be served and will be followed by a program of first class entertainment, featuring stars of the stage and radio. This banquet promises to be the highlight of the social functions.

The total price will be $7.50 per person. It is requested that as many as possible make advance reservations.

GENERAL LUNCHEON

On the opening day, August 23, a general luncheon will be held at 12:00 noon in the Terrace Room of the Fairmont Hotel. The new Institute President, J. F. Fairman, will address the group. The luncheon price will be $3 per person.

LADIES' ENTERTAINMENT

Three outstanding functions have been arranged for the ladies, and any one, or all of them, may be attended as desired.

On the afternoon of Tuesday, August 23, there will be an informal tea in the Green and Garden Rooms of the Fairmont Hotel. The time will be 3:30; the charge, $3.

On Wednesday, August 24, starting at 10:30 a.m., there will be an outing to Palo Alto and a visit to Stanford University. A specially arranged luncheon will be served at the unique tea shop, the Allied Arts. The objets d'art on display at this unusual shop will delight those attending. The complete trip, including lunch and transportation, will cost $3.

On Thursday, August 25, again starting at 10:30 a.m., there will be a tour of San Francisco, including a trip to Fisherman's Wharf, a boat cruise on beautiful San Francisco Bay, and a visit to Chinatown where luncheon will be served at the exotic Cathay House. San Francisco's Chinatown is the largest outside the Orient. The price will be $3.

Because many of the ladies will want to shop or visit while in San Francisco, no entertainment function has been arranged for Friday.

Reservations should be made by using the reservation card enclosed with the mailed announcement. It would be well to note that a "package deal" is offered which includes all ladies' entertainment functions for only $6.

STUDENT ACTIVITIES

Several student meetings have been scheduled, including a dinner on Friday evening. For the convenience of visiting students staying at the International House, a number of functions will take place on the

View of the Pacific Gas and Electric Company's Mission Station in San Francisco, Calif., to be inspected during the AIEE Pacific General Meeting in that city, August 23–26

Tentative Technical Program

Pacific General Meeting, San Francisco, Calif., August 23-26

Monday, August 22

7:30–9:30 p.m. Advance Registration—Main Lobby, Fairmont Hotel

Tuesday, August 23

8:30 a.m. Registration—Main Lobby, Fairmont Hotel

10:00 a.m. Opening of Meeting

George C. Tenney, Chairman

Welcome: Professor T. C. McFarland, Chairman, San Francisco Section

10:15 a.m. General Session

George C. Tenney, Chairman

Address: "The Social and Economic Responsibilities of the Engineer." W. C. Mullendore, President, Southern California Edison Company, Ltd.

12:00 m. Luncheon Meeting

All AIEE members, guests, and ladies welcome.

Address: "Our Institute and Its Future." James F. Fairman, President, AIEE

2:00 p.m. Power Generation and Distribution

W. R. Johnson, presiding

CP. Electric Load Growth in California for the Next 20 Years.** *R. P. O'Brien*, California Public Utility Commission

CP. The New Swedish 380-Kv System Now Under Construction.** *A. Rusck*, Swedish State Power Board

49-200-ACO.* Postwar Planning for High-Voltage Transmission in Northern California. *W. R. Johnson*, Pacific Gas and Electric Company

CP. Application of Series Capacitor and Double Conductors in the Swedish Long-Distance Transmission System.** *B. Rathman*, Swedish State Power Board

2:00 p.m. Air Transportation

S. D. Summers, presiding

CP. A New Aircraft D-C Generator Control System.** *G. A. Phillips*, General Electric Company

49-201-ACO.* Directional Current Circuit Protector. *C. E. Gagnier, E. L. Coustin*, Carma Manufacturing Company

49-202. Current Rating of Aircraft Cable. *W. H. Astew, A. T. McClinton*, Naval Research Laboratory

CP. 30-Volt D-C and 120-Volt D-C Aircraft Circuit Breakers.** *P. J. Reifschneider, B. S. Boall, III*, General Electric Company

48–203. Protection of the Airplane Main Bus. *D. W. Exner*, Boeing Airplane Company. Presentation by title only

7:00 p.m. Meeting—District, Section, and National Officers and Student Counselors

*ACO: Advance copies only available; not intended for publication in *Transactions*.

**CP: Conference paper; no advance copies are available; not intended for publication in *Transactions*.

Wednesday, August 24

9:00 a.m. Inspection Trip, Station P Steam Plant, Pacific Gas and Electric Company

9:00 a.m. Home Heating Symposium

J. C. Beckett, presiding

CP. Electric Space Heating Methods.** *Stuart Forsyth*, Westinghouse Electric Corporation

CP. Effect of Increased Residential Space Heating on Power System Economics.** *G. E. Bishop*, Coast Counties Gas and Electric Company

CP. Power Distribution for Electric Space Heating.** *B. H. Martin*, Tennessee Valley Authority

CP. Heat Pump Experience in Portland, Oreg. Area.** *W. E. Gordon*, Portland General Electric Company

CP. Electric Space Heating Load Control.** *J. C. Beckett*, Wesix Electric Heater Company

9:30 a.m. Power and Instruments

Lloyd F. Hunt, presiding

CP. Comparison of American and Foreign Practice of High-Voltage Transmission and Generation.** *Lloyd F. Hunt*, Southern California Edison Company

49-203-ACO. When Should a Generator Be Rewound? *E. A. Crellin*, Pacific Gas and Electric Company

49-221. Insulator Flashover De-ionization Times as a Factor in Applying High-Speed Reclosing Circuit Breakers. *A. C. Boisseau, B. W. Wyman, W. F. Skeats*, General Electric Company

49-205. Deionization Time of High-Voltage Fault-Arc Paths. *E. J. Harrington*, Bonneville Power Administration; *E. C. Starr*, Oregon State College

49-206. A Transient Fault Locator for High-Voltage Transmission Lines. *L. R. Spaulding, C. C. Diemond*, Bonneville Power Administration

—PAMPHLET reproductions of author's manuscripts of the numbered papers listed in the program may be obtained as noted in the following paragraphs.

—PRICES for papers, irrespective of length, are 30 cents to members (60 cents to nonmembers) whether ordered by mail or purchased at the meeting. Mail orders are advisable, particularly from out-of-town members, as an adequate supply of each paper at the meeting cannot be assured. Only numbered papers are available in pamphlet form.

—COUPON books in nine-dollar denominations are available for those who may wish this convenient form of remittance.

—THE PAPERS regularly approved by the technical program committee ultimately will be published in Proceedings and Transactions; also, each is scheduled to be published in Electrical Engineering in digest or other form.

9:30 a.m. Air Transportation

H. F. Rempt, presiding

CP. A 120-Volt D-C Multiple Generator Aircraft Electric System.** *J. D. Miner, R. J. Luck*, Westinghouse Electric Corporation

49-207. Weight of the 120-Volt D-C System Versus the 3-Phase 208-Volt 400-Cycle A-C System. *W. F. Moore*, General Electric Company

CP. A Generator Control and Protective Panel for 120-Volt D-C Aircraft System.** *D. E. Fritz, O. C. Wallis*, Jack and Heintz Precision Industries, Inc.

49-219-ACO.* D-C Power Supplies and Starters for Starting Aircraft Jet Engines. *P. T. Kwigonis*, Jack and Heintz Precision Industries, Inc.

48-229. A Rectified A-C Electric System for Aircraft. *L. M. Cobb, W. L. Kershaw, Q. E. Erlandson*, Glenn L. Martin Company. Presentation by title only

2:00 p.m. Power Generation and Distribution

Noel B. Hinson, presiding

49-208. Electrical Design Features, Steam Electric Generating, Station P. *F. S. Benson*, Pacific Gas and Electric Company

CP. Automatic Supervisory Control of Remote Hydroelectric Power Plants.** *R. F. Hind, C. L. Killgore*, United States Bureau of Reclamation

CP. Transformer Grounding Neutral Current Limitation With Neutral-Voltage Shift During Ground Faults.** *Martin J. Lantz*, Bonneville Power Administration

49-209. Matching Electrical Characteristics of McNary Generators and Transformers With Bonneville Power Administration System. *B. V. Hoard, Lewis Weiner*, Bonneville Power Administration

2:00 p.m. Electronics and Communications

R. D. Miller, presiding

CP. Expanding the Pacific Coast Telephone Network.** *D. I. Cone, C. V. Fowler*, Pacific Telephone and Telegraph Company

49-210. A Proposal for Broad-Band Coupling of Power-Line Carrier Equipment. *R. H. Miller*, Pacific Gas and Electric Company

49-211-ACO.* Modern Carrier Current Test Equipment and Its Application. *R. L. Brinton*, Pacific Gas and Electric Company

CP. Sound-Powered Telephone Systems.** *A. P. Egerman*, San Francisco Naval Shipyard

2:00 p.m. Air Transportation

W. V. Boughton, presiding

CP. Problems of Designing 120-Volt D-C Aircraft Generators.** *A. Fisher*, General Electric Company

49-213-ACO.* The Design of Insulating Systems for Small Rotating Machines by the Determination of Corona Starting Voltage. *R. D. Jones, E. M. Stanbery*, General Electric Company

CP. Flexural Vibration in Aircraft Engine Accessories.** *Irving Kalikow*, General Electric Company

CP. A Modern Air Transport Generator Protection System.** *C. A. Tolver*, Lockheed Aircraft Corporation

48-214. Aircraft Carbon-Pile Voltage Regulators, Fundamentals, and Design Improvements. *B. O. Austin, H. H. C. Richards*, Westinghouse Electric Corporation. Presentation by title only

1:30 p.m. Inspection Trip to Radiation Laboratory, University of California

7:30 p.m. Meeting of Student Branch Officers and Counselors—University of California

Thursday, August 25

9:00 a.m. Inspection Trip to San Francisco Naval Shipyard, Hunter's Point

9:00 a.m. Inspection of Pacific Gas and Electric Company Calculating Board

9:30 a.m. Industrial

Ralph A. Hopkins, presiding

CP. Steel and Electricity in Partnership at Columbia Steel's New Mill at Pittsburg, Calif.** *George L. Bosner*, General Electric Company

49-215-ACO.* Series Capacitors to Correct Voltage Fluctuations Caused by Induction Motors. *T. A. Butterworth*, Pacific Gas and Electric Company

49-216. Dielectric Strength of Oil With Variations of Pressure and Temperature. *W. G. Hoover, W. A. Hixson*, Stanford University

49-217-ACO.* Electrical Design Features of Mission Substation, a High-Voltage Subtransmission Station in San Francisco. *Einar Nilsson*, Pacific Gas and Electric Company

9:30 a.m. Air Transportation

Karl Martinez, presiding

Conference on Aircraft Electric System Protection

CP. Philosophy of Aircraft Electric System Protection.** *L. R. Larson*, Naval Research Laboratory

10:00 a.m. Conference Meeting on Calculating Board Operation

Dr. A. Tilles, presiding

12:00 m. Golf at Peninsula Golf and Country Club, San Mateo

1:30 p.m. Inspection Trip to Mission Substation, Pacific Gas and Electric Company

2:00 p.m. Air Transportation

Karl Martinez, presiding

Conference on Aircraft Electric Systems

CP. A New Approach to Aircraft Electric Systems.** *E. F. Kosnik*, Consolidated Vultee Aircraft Corporation

7:30 p.m. Banquet and Presentation of Golf Prizes

Informal—Entertainment

Friday, August 26

9:00 a.m. Inspection Trip to New Regional Automatic Toll Switching Center

The Pacific Telephone and Telegraph Company, Franklin Building, Oakland

9:30 a.m. Student Session

Professor I. J. Sandorf, presiding

CP. Topographic Presentation Radar.** *Walter Hirshberg*, California Institute of Technology

CP. Design of a Tit-Tat-Toe Machine.** *Robert Haufe*, California Institute of Technology

CP. Protection of Polyphase Machines From Unbalanced Voltages.** *Joe Tlarraz*, University of Santa Clara

CP. An Electronic Flux Meter.** *P. B. Gallagher*, University of Santa Clara

9:30 a.m. Air Transportation

C. F. McCabe, presiding

49-223. Lightweight Aircraft Transformers. *D. S. Stephens*, Westinghouse Electric Corporation

CP. A Phase Adapter for Aircraft.** *F. W. Maxstadt*, California Institute of Technology

49-218. An Electric De-icing System for Aircraft. *E. W. Giley*, Glenn L. Martin Company

49-214. Lightning Stroke Damage to Aircraft. *J. H. Hagenguth*, General Electric Company

49-224. Analysis of Relay Servomechanisms. *D. A. Kahn*, Curtiss-Wright Corporation

49-222. Development and Application of Electric Heating to De-icing of Aircraft Propellers. *J. H. Sheetz, E. J. Sand*, Curtiss-Wright Corporation. Presentation by title only

1:30 p.m. Inspection Trip to Columbia Steel Company, Pittsburg, Calif.

1:30 p.m. Inspection Trip to Ames Aeronautical Laboratory, Moffett Field

2:00 p.m. Electronics and Science

D. I. Cone, presiding

CP. The University of California Proton Synchrotron.** *G. M. Early*, University of California Radiation Laboratory

CP. The Stanford Linear Accelerator.** *R. F. Post*, Stanford University

CP. The Outlook for the Nuclear Power Plant.** *Dr. I. Perlman*, University of California Radiation Laboratory

CP. Radiac Instruments.** *C. E. Parker*, San Francisco Naval Shipyard

2:00 p.m. Power Generation and Distribution

Waldo E. Enns, presiding

49-220-ACO.* 220-Kv Transmission Line Tests to Midway. *E. M. Wright*, Pacific Gas and Electric Company

49-204. Some Oscillographic Methods of Investigating Mechanical and Hydraulic Conditions During Operation of Hydraulic Units. *L. R. Engvall*, Bureau of Reclamation

CP. Tests of Load Interrupter Switches for 115-Kv Service.** *O. A. Demuth, H. L. Rorden*, Bonneville Power Administration

CP. Field Tests on 115-Kv Interrupter Switch.** (*a*). *A. C. Schwager*, Schwager-Wood Corporation

(*b*). *P. B. Hoyt*, Electrical Engineers Equipment Company

(*c*). *R. F. Gibbons*, Pacific Electric Manufacturing Corporation

49-212. Magnetic Heating of Transmission Line Clamps. *V. L. Crabb, J. M. Shoudel*, The Ohio Brass Company

CP. Conductor Armor for Reinforcement, Damping, Splicing, and Repair.** *T. F. Peterson, J. C. Little*, American Steel and Wire Company

2:00 p.m. Student Session

University of California

Professor V. L. Palmer, presiding

6:30 p.m. Student Dinner and Meeting

University of California

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campus of the University of California at Berkeley.

INSPECTION TRIPS

The committee has arranged a group of inspection trips to important electrical installations in the San Francisco Bay Area. Each member, regardless of his interests, certainly will find one or more trips appealing.

1. Station P, Pacific Gas and Electric Company, San Francisco. This station is the newest steam turbine generating plant of the Pacific Gas and Electric Company. The second 110,000-kw generator recently has gone into service. All parts of this modern station will be inspected.

2. Radiation Laboratory, University of California, Berkeley. The University of California Radiation Laboratory, which is the headquarters of the renowned Nobel prize winning physicist, Dr. Ernest O. Lawrence, has the world's largest Cyclotron, ten times more powerful than any other nuclear accelerator. In addition to the Cyclotron, other facilities of this outstanding laboratory will be viewed.

3. Network Calculator—Pacific Gas and Electric Company, San Francisco. The new Pacific Gas and Electric Company's a-c network calculator is of the most modern type. It includes facilities to simulate 14 generators, 164 line impedance units, 48 loads, and 80 auxiliary units.

4. United States Naval Shipyard, Hunters Point, San Francisco. There are several unique electrical installations at the San Francisco Naval Shipyard. The nation's largest drydock includes an underground network distribution system; the yard has the world's mightiest electric crane; and the electronic and instrument shops are unsurpassed.

5. Mission Substation, Pacific Gas and Electric Company, San Francisco. Mission Substation is a completely indoor, 110,000-volt station located in a heavily congested area in the city of San Francisco. The building itself and the installed equipment include many novel and unusual design features.

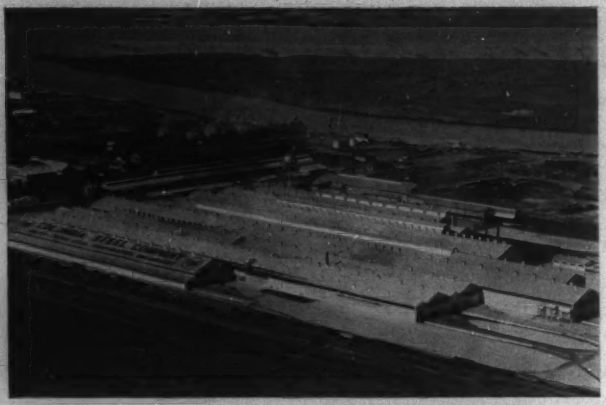
6. Columbia Steel Company, Pittsburg, Calif. Of particular interest at Columbia is the new continuous tin plate installation. Modern electric drives are used on the pickling line, cold reduction mill, electrolytic cleaning line, the temper mills, trimming and shearing lines, and tinning lines.

7. Ames Laboratory, National Advisory Committee for Aeronautics, Moffett Field, Calif. Ames Laboratory has ten wind tunnels in operation, the larger ones requiring 36,000 and 50,000 driving horsepower. The more important of these installations will be included in the inspection.

8. Pacific Telephone and Telegraph Company, Oakland. The new Oakland Telephone building now being completed will be the regional switching center for northern California, western Nevada, and the Pacific Northwest. The installation of crossbar toll dialing equipment is the first west of Chicago and will work with similar installations in Philadelphia, New York, Boston, Cleveland, and Chicago.

GOLF

The annual golf tournament will be held at the Penninsula Golf and Country Club in San Mateo County, on Thursday after-



Among the inspection trips scheduled for the AIEE Pacific General Meeting in San Francisco, Calif., August 23–26, is this new sheet and tin plate mill at the Pittsburg, Calif., plant of the Columbia Steel Company

noon, August 25, at 12:00 noon. Players are assured of perfect golfing weather since the automatic air conditioning, normal in San Francisco in August, will not be turned on.

Where desired, arrangements will be made for play in foursomes. All arrangements will be made by the Golf Committee at hotel headquarters.

Competition will be medal play on handicap. AIEE members will be playing for the John B. Fisken Cup. There will be other prizes for low gross and also low net, and numerous prizes based on handicaps worked out by the committee.

The greens fee for the tournament will be $3.50.

Transportation will be furnished to and from the course, when desired. Luncheon may be had at the club by prior reservation with the committee. Return to the Fairmont Hotel will be in ample time to prepare for the banquet where the prizes will be awarded.

COMMITTEE

All arrangements for the Pacific General Meeting have been completed by the committee working with the General Chairman, George C. Tenney.

Members of the General Committee are the following:

George C. Tenney, *Chairman;* C. E. Baugh, *Vice-Chairman;* J. A. Robinson, *Secretary;* W. F. Poynter, *Treasurer;* J. L. Buckley, *Registration;* D. I. Anzini, *Program;* R. O. Broesmer, *Hotel;* I. W. Borda, *Entertainment and Reception;* W. J. Warren, *Student Activities;* W. R. Nodder, *Trips and Local Transportation;* H. C. Verwoert, *Transportation;* W. L. Winter, *Sports;* Remi Bollaert, *Publicity*

Successful Summer General Meeting Held at Swampscott, Mass., June 20-24

The 65th Summer General Meeting of the Institute, which was held in Swampscott, Mass., with headquarters in the New Ocean House, June 20–24, 1949, was highly successful. The success of the meeting may be attributed to a combination of factors: the broad technical program of 30 sessions and conferences covering practically the whole range of Institute technical activities; 50 committee meetings, in addition to an all-day meeting of the Board of Directors; several Section Delegates Conferences; and the Annual Meeting. Affairs were well organized, and smoothly conducted by the Summer General Meeting Committee which provided an excellent program of inspection trips, entertainment, and a special program for the visiting ladies. The total attendance of 1,650 established an all-time record for Summer General Meetings, and exceeded the number which attended the Montreal meeting two years ago by 13.7 per cent.

ANNUAL MEETING

The Annual Meeting was held on Wednesday morning, June 22, with President Everett S. Lee presiding.

The Report of the Board of Directors was reviewed briefly by Secretary Henline who drew attention to the several divisions; President's visits to the General and District meetings, as well as many of the Sections and Branches; the table which shows that over two times as many Section meetings were held as compared with five years ago; the growth in membership with more than 1,500 new members in April; the technical activities with 30 out of 31 committees reporting; and the financial statements of the auditors. (For details, see complete report in this issue, pages 718–43.) In conclusion, Mr. Henline expressed the appreciation of the Directors for the highly effective work of the national committees, the Districts, Sections, and Branch officers and committees. In the absence of the Treasurer, W. I. Slichter, Secretary Henline reviewed the finances of the Institute, and President Lee paid tribute to Professor Slichter for his long and faithful services.

The next item of business consisted of a report of the Committee of Tellers, and the votes cast for AIEE offices. Out of 10,353 ballots cast, 231 were invalid; leaving 10,122 valid which elected the following officers for the administrative year beginning August 1:

1. *President*

James F. Fairman

2. *Vice-Presidents*

C. G. Veinott, District 2
W. J. Seeley, District 4
W. C. Du Vall, District 6
R. A. Hopkins, District 8
A. H. Frampton, District 10

3. *Directors*

E. W. Davis, Cambridge, Mass.
N. B. Hinson, Los Angeles, Calif.
H. J. Scholz, Birmingham, Ala.

4. *Treasurer*

W. I. Slichter, New York, N. Y.

President Lee introduced President-elect James F. Fairman, and presented him with the President's Badge. Mr. Fairman's response dealt with "Engineering Organization" and is published in full on page 693 of this issue.

The Lamme Medal was presented to V. K. Zworykin by President Lee. The medal was awarded to Dr. Zworykin for "his outstanding contribution to the concept and design of electronic apparatus basic to modern television." The Lamme Medal and its establishment was described by N. S. Hibshman, Chairman of the Lamme Medal Committee. The Medalist's career was given by General David Sarnoff, Chairman of the Board of the Radio Corporation of America, and in response, Dr. Zworykin addressed the meeting on "The Engineer's Role in the Progress of Science." These addresses are published in full in this issue, pages 670–2.

In an address, "The Expanding Horizons in Engineering Education," given by William F. Ryan, Engineering Manager, Stone and Webster Engineering Corporation, Mr. Ryan drew attention to the need to develop engineers more broadly, particularly with respect to professional status, registration, ethics, and so forth. He commended the Carnegie Institute of Technology for its training program on basic philosophy and drew attention to the Canadian ritual, Dr. Bush's description of a profession as a "ministry to the people," the ECPD Canons of Ethics, and the Code of Ethics of the American Medical Association. He suggested meetings in each college where all engineering students together would learn about professional development. In conclusion, Mr. Ryan complimented the Institute for having studied the problem from the fundamentals in the grass roots. He exhorted the Institute to do everything within its power to integrate the profession and pointed out that everything should be done to inspire the integration of engineering students in the schools.

A TRIBUTE TO MR. FAIRMAN

Preceding his address, Mr. Ryan, who also is Vice-President of the Northeastern Section of the National Society of Professional

Future AIEE Meetings

Pacific General Meeting
Fairmont Hotel, San Francisco, Calif.
August 23–26, 1949
(Final date for submitting papers—closed)

Fall General Meeting
Netherland Plaza Hotel, Cincinnati, Ohio
October 17–21, 1949
(Final date for submitting papers—closed)

AIEE/IRE Conference on Electronic Instrumentation in Nucleonics and Medicine
Hotel Commodore, New York, N. Y.
October 31–November 2, 1949

AIEE Conference on Electric Power Supply for Industrial Plants
Pittsburgh, Pa.
November 1949

Winter General Meeting
New York, N. Y.
January 30–February 3, 1950
(Final date for submitting papers—November 1)

AIEE Conference on Meeting Load Demands With Limited Reserve
Pittsburgh, Pa.
April 1950

AIEE Conference on Electrical Engineering Problems in the Rubber and Plastics Industry
Akron, Ohio
April 1950

AIEE Conference on Electric Welding
Detroit, Mich.
April 12–14, 1950

North Eastern District Meeting
Providence, R. I.
April 26–28, 1950
(Final date for submitting papers—January 26)

Great Lakes District Meeting
Jackson, Mich.
May 11–12, 1950
(Final date for submitting papers—February 10)

Summer and Pacific General Meeting
Huntington Hotel, Pasadena, Calif.
June 12–16, 1950
(Final date for submitting papers—March 14)

1950 Fall General Meeting
Oklahoma City, Okla.
October 23–27, 1950
(Final date for submitting paper—July 25)

Engineers, presented President-elect James F. Fairman with a tribute of esteem from his friends across the country. The gift was a richly bound album in red and gold containing congratulatory letters from the President, Vice-Presidents, and Executive Secretary of NSPE, as well as letters from the Presidents of many of the State Societies. This friendly act served to illustrate the good will and close relationship between NSPE and AIEE, a number of whose officers and members are also members of the Institute.

The album was sponsored by the Massachusetts Society of Professional Engineers and in making the presentation, Mr. Ryan said:

Whether the Brooklyn Dodgers win, lose, or get rained out this afternoon, bands will play and flags will fly in Brooklyn. "Their boy" has not struck out.

Joy in the installation of James F. Fairman as President of AIEE is not confined to Brooklyn. Throughout the nation, local chapters, state boards, and national officers of the National Society of Professional Engineers are rejoicing that "their boy" has received this recognition. I have your chairman's permision to interrupt these proceedings for a moment, in their behalf.

Jim, our audience will be relieved to know that this weighty tome is not my manuscript, but is the written expression of esteem and affection from every national officer of NSPE and every president of the constituent state societies, all of whom wish you a happy and successful administration. They promise their active co-operation with you and with the Institute in achieving a realization of the professional aspirations of the engineer.

The meeting concluded with an inspiring address, "Open Doors," by President Everett S. Lee, which drew attention to the engineering achievements and the work of the Institute which he had seen on various visits to the Sections, Branches, and Institute meetings. The address, published in full on pages 692 and 694 of this issue, suggests a philosophy of life for engineers whereby they may open doors by taking part in civic and other activities, telling their fellowmen of engineering achievements, and thus obtaining recognition for the profession.

INSTITUTE PUBLICITY AND POLICY

The first meeting of Section Delegates was divided into two parts: "Section Publicity" with C. S. Purnell, Vice-Chairman of the Sections Committee, presiding; and "Institute Policy" with M. D. Hooven, Chairman; J. L. Callahan, and R. T. Henry comprising a special committee appointed by the Board of Directors. (See "Membership Views Sought on Institute Policy," published in *Electrical Engineering*, June 1949, page 536.)

Institute Publicity. The purpose of the meeting was explained by J. C. Strasbourger, Chairman of the Sections Committee, who said that the value of the Institute to its members would be greatly increased if the communities became familiar with the aims, objectives, and accomplishments of the Institute. To present this information to the public properly has been the function of the Publicity Committees in the Sections and as an aid in the task, a new tool, the "Publicity Kit," has been prepared.

On behalf of R. K. Honaman, Chairman, of the Public Relations Committee, which prepared the publicity kit, G. T. Minasian explained the importance of public knowledge of Institute activities. Because the advancement of the theory and practice of electrical engineering is important to the public welfare, it is to the interest of both the Institute and its members, as well as the public, to have a full knowledge of steps being taken by the Institute in obtaining progress. An active publicity program should reflect continuously the Institute's responsible and authoritative leadership in the scientific and engineering world. In regard to the publicity kit, Mr. Minasian explained that it gave the why, when, where, what, and how of publicity, with some examples that have proved effective. Some suggestions may be trite and repeat what publicity committees already know, nevertheless parts of the material will be found of valuable assistance.

As an illustration of successful publicity, M. C. Thurling of the Montreal Section explained that his Section had a man who knew how to write releases and who also knew the contacts with the press. Now the Section is well-known in the community, strong in its knowledge of service, and its meetings are well attended by members who are proud of their organization.

The work of the paid publicity man for the Winter General Meeting which was held in Pittsburgh a few years ago was explained by M. Getting, Chairman of the Publicity Committee. The dramatic angles of getting stories across such as the presence of women engineers, and interviews with Hindu and Moslem engineers present, at a time immediately after the death of Mahatma Ghandi, were helpful in obtaining space in newspapers.

The mechanics of news releases, which was prepared by Guy Bartlett, who has had a wealth of experience in this field, was presented by C. S. Purnell in his absence. Mr. Bartlett covered the style of the release; the need to be brief and tell the whole story in the first paragraph; the need to prepare two stories, for morning and afternoon papers; the proper relations with press representatives, such as inviting them to social functions; and the way in which to telephone the facts of stories to reporters.

With regard to news stories for *Electrical*

photo courtesy *Electrical World*

AIEE President-elect James F. Fairman (left) receives an album of congratulatory letters presented by William F. Ryan, Vice-President of the Northeastern Section of the National Society of Professional Engineers, as a tribute of esteem from NSPE officers and members. The presentation was made during the Summer General Meeting

Engineering, the editor, C. S. Rich, explained the importance of the timing and a general criterion for acceptance. The magazine is mailed between the 20th and 22d of the preceding month. About a week's time must be allowed for printing and binding; another week for preparing the material in page form; and another week for setting it and getting it in galley form; which means that all stories must be received before the first—a month in advance of publication. Material which might have to be held over another month loses its timeliness and news value. In respect to the criterion for acceptance, ask yourself if you would read the story with interest if you were a member of some other Section. Good photographs of groups with each member of the group properly identified, or pictures of the principal speaker, are always of value, and may be used to advantage with suitable caption to tell the gist of the story when make-up considerations in any one month might not permit use of the whole story in detail.

In conclusion, various views were expressed by those who have had long experience in Section affairs. Publicity to be effective must be continuous. Some circles of smaller Sections are getting good publicity now. The need was generally felt to have Publicity Committees in the Sections which would know the effective material and have the necessary contacts with the press. In response to requests, President Lee summarized the success of a person as: ability—what you can do; personality—what people think of you when your name is mentioned; character—what you are. The program should be such that each engineer in the Section is a better engineer at the end of the year. Every member should see himself in Section activities and publicity affords the opportunity for making the member conscious that he is active in his community and electrical engineering. A suggestion was made that a reference should be added to the kit citing the 1927 article "Civilization and the Engineer," by Bancroft Gherardi which tells what the engineer has done for the public and humanity. Another suggestion was made to the effect that the publicity kits would be valuable to Counselors of the Student Branches.

Institute Policy. In introducing the subject of "Institute Policy," Walter C. Smith, Director from District 8, outlined the problems confronting the Institute which led to the adoption of the resolution reported in the previous reference, *Electrical Engineering*, July 1949, page 536. Some years ago, the United States entered into an era of policies which vitally have affected the social and economic outlook of the young engineer. These policies involved labor union affiliations, collective bargaining, professional status, so-called security, salary levels, job classifications, registration, taxation, employers' practices, and so on. As an individual, the engineer is practically helpless in endeavoring to control or guide these matters, and some society or group of societies must take up the challenge. Institute efforts have been meager due to lack of funds, personnel, and plans effectively to carry out the interests of the younger members particularly in such matters. He further explained that the Institute is having a difficult time in keeping its budget balanced with the present dues. There is a real additional job to be done in handling the nontechnical interests of the members. Should the Institute materially raise the dues and go after these other activities which are far removed from the technical or should all its energies be put into expanding the technical interests of the members? Should the nontechnical activities be carried out by the proposed American Engineering Association (Plan D) or the National Society of Professional Engineers or some other body? Recently the Board of Directors was confronted with a New York State tax investigation. Then the California Sections were asked to join and support the California Legislative Council which organization maintained a lawyer at the state capital to watch legislation, particularly regarding registration. At this point the resolution previously referred to was drafted, not for an immediate decision, but to provoke discussion throughout the membership so that a proper determination may be made as to what future policy should be, and then to take vigorous action along lines as indicated.

In discussion of the resolution representatives from various Sections of the country held different views about the matter. In the regions of Boston, Arizona, Houston, and Georgia, it was reported that the majority of members favored the Smith resolution. Those favoring the resolution reported that they were able effectively to carry out professional activities through the National Society for Professional Engineers or strong state societies. Some feeling was expressed that becoming a political pressure group was not compatible with the progress of going forward by building personality and character. In the regions of Oklahoma, Florida, Austin, San Antonio, and Schenectady, hope was expressed that Plan D for an American Society of Engineers to carry out professional activities soon would be put into effect. This plan meets with the favor of many of the younger members. In the vicinity of Cleveland, St. Louis, Michigan, and Erie, representatives were strongly opposed to the Smith resolution. Those opposed to the resolution believed that now was not an appropriate time for its introduction, and that it would close the door to improving the status of the engineer, and even prevent participation in local engineering councils.

T. G. Le Clair, who was Chairman of the Professional Activities Committee which drafted the four plans for organization of the engineering profession voted on by questionnaire more than two years ago, explained that a majority were in favor of Plan D for an American Society of Engineers which would carry out all professional activities while present societies would continue to function in their respective fields of technical interests.

President Lee addressed the meeting and summarized the steps taken and showed how they all tied together. He marvelled at the great strength of the Institute in arriving at strong and substantial conclusions and he expressed confidence that it would come up with the right answer.

The entire problem was reviewed by President-elect James F. Fairman who has had long experience with the organization of the engineering profession. He explained that he was neutral in regard to the matter and wanted to find out what the members thought about the problem. He warned that formal adoption of an over-all plan is some years ahead. For example, the study was started four years ago when Dr. Wickenden was AIEE President, and it took two years to reach a conclusion in favor of Plan D. The Institute by itself could do nothing about Plan D, and it was referred to Engineers Joint Council which has appointed a Committee on Unity. Since then two more years have passed during which there were constant conversations, explorations, and conferences, with representatives from the national engineering societies, and recently invitations have been issued to representatives for a conference on the matter in October. Probably another four years will be required before formal adoption of the

photo courtesy *Electrical World*

AIEE President E. S. Lee (left) presents the Lamme Medal for 1948 to V. K. Zworykin of the Radio Corporation of America during ceremonies at the recent Summer General Meeting, while N. S. Hibshman, Chairman of the Lamme Medal Committee, looks on

plan, and perhaps 40 years. Mr. Fairman advised that a good beginning had been made, but only a beginning and the real hard work lies ahead. He was hopeful that inasmuch as the conference is going to be held, something good will come out of it.

In conclusion, Mr. Fairman explained that the Institute has a problem during the interim, hence the occasion for the Smith resolution. The Board of Directors has problems to solve at every Board meeting, and the handling of nontechnical activities will require a staff, committee, organization, and money. Does AIEE want to expand and spend money as an interim measure? It would be desirable to continue co-operation with EJC on these matters. The Board of Directors would like a more definite expression of sentiments on the problem and a more specific guide in regard to these nontechnical activities. (See "Engineering Organization" by James F. Fairman, President AIEE 1949–50, page 693, this issue.)

SECTION DELEGATES' CONFERENCE

The second Conference of Section Delegates was called to order at 1:40 p.m. on Tuesday, with J. C. Strasbourger, Chairman of the Sections Committee, presiding; T. J. Martin, Secretary. The agenda included such important items as "New Sections and Territorial Changes," "Prize Paper Rules," "Lists of Speakers," "Section Finances," "Institute Affairs," and "Recognition of Past Section Chairmen."

New Sections and Territorial Changes. On the motion of J. M. Somerville of Toronto, which was seconded by N. C. Pearcy, the conference recommended to the Board of Directors that the Ottawa Subsection of the Montreal Section be granted Section status to be known as "Ottawa Section" and to include specific counties formerly a part of the Montreal Section.

On the motion of Llewellyn Saunders of Virginia and seconded by L. W. Roush of West Virginia, the conference recommended to the Board of Directors that the Western Virginia Subsection of the Virginia Section be granted Section status to be known as "Western Virginia Section" and that its territory include specific counties which were a part of the Virginia Section.

On the motion of Roger Merrill of the Columbus Section, which was seconded by G. W. Bower, Vice-President of District 2, the conference recommended that Hardin County, Ohio, be transferred from the territory of the Columbus Section to that of the Dayton Section to permit residents of Hardin County to become affiliated with the newly formed nearby Lima Subsection of the Dayton Section.

After an expression of views by A. H. Frampton, Vice-President-elect of the Canadian District and J. H. Steede of the Vancouver Section, the motion was made by H. A. Dambly, seconded by W. J. Barrett, to recommend to the Board of Directors that the Vancouver Section be transferred from District 10 to District 9 for AIEE administrative purposes and that a travel allowance be provided for the Canadian Vice-President to visit the Vancouver Section in reference to all matters exclusively of Canadian interest.

On recommendation of W. J. Barrett, which was seconded by C. S. Purnell, the conference recommended that Subsections San Juan and Mayaguez which are Subsections of the New York Section in Puerto Rico be transferred back to the territory of District 3 because of inactivity.

On motion of Professor F. H. Pumphrey of the Florida Section which was seconded by H. J. Scholz, the conference recommended to the Board of Directors that specific counties in the Panhandle of Florida and now a part of the Florida Section be transferred to the Mobile Subsection of the Alabama Section because of their proximity to Mobile, Ala.

As explained by Vice-President J. H. Berry, the number of members of the Muscle Shoals Section is below minimum with no possibility of obtaining additional members. The conference voted to recommend to the Board, on motion by G. W. Bower, which was seconded by T. D. Talmage, that the Muscle Shoals Section be changed to the status of a Subsection and the territory added to the East Tennessee Section as the interests of members in the Muscle Shoals territory are more closely allied with the interests of the East Tennessee Section than the Alabama Section.

Prize Paper Rules. The second draft of Prize Paper Rules was submitted by Fischer Black who gave the background in regard to the need for changes in the rules, and outlined the estimated cost to the Institute of the proposed changes as compared with present costs during several preceding years. After discussion, the draft of prizes for technical papers, with minor changes approved at this meeting, was accepted by the conference for transmission to the Committee on Planning and Co-ordination. The minor changes consisted of setting up a separate category for communications papers; establishing the Section prize of $100 to be divided at the discretion of the Section with a maximum of $50 for any one prize and certificates for each winner; permitting coauthors to split the prize money, with a certificate for each; substitution of an equivalent gift where cash receipts are not permitted; and a few minor changes in wording to clarify meanings.

Membership. Fischer Black, Chairman of the Membership Committee, attributed the increase in number of members, which is greater than ever before, to the activities of the Sections and committees, as well as to the transfer of Students to the Sections. He urged that the Sections appoint Membership Committees as soon as possible, that they keep files, and that they have a Membership Committee man familiar with matters present at each meeting with membership blanks for prospective applicants.

Speakers' List. A special committee consisting of W. J. Barrett and C. S. Purnell assigned to study the matter reported that there was no longer a need to send out a list of Section speakers from headquarters inasmuch as the labor involved is out of proportion to the benefits derived therefrom. The conference adopted the report which recommended that the Sections place principal reliance for speakers upon local members, and that if a Section wishes to have a speaker on a particular subject for which no local speaker is available, the Section should communicate directly with the Secretary of the appropriate technical committee and request suggestions as to available speakers.

Section Finances. The subject of "Section Finances" was introduced by Vice-President G. W. Bower with the view toward determining how the Sections are meeting their financial requirements, as the problem is related to the Institute's "Five-Year Estimate of Expenses." In the discussion, various Sections explained the different ways in which they are meeting the problems—such as a meeting place from a local industry, inexpensive printing, conducting educational courses to raise extra money, and assessing members to help defray the cost of refreshments, in the case of dinners for students, and charging a price of 50 cents partly to defray the cost of the meal. One or two Sections reported that activities were changing so rapidly that it was impossible to say what the expenses might be during the next five years. In conclusion, Mr. Bower requested that the Sections put their ideas in writing which would be helpful to the other Sections, and said that those who already have submitted 5-year estimates should not hesitate to revise them. The need for good planning to spend money conservatively and wisely was stressed.

Recognition of Past Section Chairmen. Several of the Sections reported the ways in which they have recognized past Section Chairmen. In the New Orleans Section, a key was designed by a jeweler which was made for $15. The San Francisco Section advised that they held a meeting to honor the Past Chairman once a year, usually the night of the President's visit. The Arkansas Section has provided the retiring chairmen with an engraved aluminum gavel. After the discussion, the conference adopted the following resolution:

> Resolved that the Sections Committee respectfully requests that the Board of Directors provide each Section Chairman, as he retires from office, a suitably inscribed certificate signed by the President and Secretary of the Institute, in appreciation of services rendered; and that each past Section Chairman be entitled to wear a specially modified AIEE emblem, to be known as the "Past Section Chairman's Emblem," to be purchased from Institute Headquarters. This resolution is retroactive for past Chairmen.

The resolution has been referred to the Committee on Planning and Co-ordination.

Institute Affairs. President Lee commented on Institute affairs and the great strength of the Institute which he attributed to the officers that have gone before in previous administrations. He urged that the same thought and analysis be put into Institute activities that is put into private business. The Institute has been doing just that which is the reason why it is over 32,000 strong today. He stated that under the plan for a balanced budget the deficit at the present time had been reduced to $18,000; whereas a year ago it was $40,000.

As another illustration of untiring individual effort, President Lee cited that Past-President H. S. Osborne had been working hard in Engineers Joint Council so that President-elect James F. Fairman could announce that letters of invitation to a conference on over-all engineering organization had gone out to the several societies. In conclusion, President Lee thanked the Sections for their support during the past year, expressed confidence in the future, and introduced his successor, President-elect James F. Fairman.

In reply, Mr. Fairman drew on several observations. He remarked that when the

Summer General Meeting was held in Swampscott nine years ago, the Section Delegates' Conference took not too much of one afternoon's time; whereas now several sessions are required. Similarly about four years ago, the Board of Directors began to find so much business in their meetings that they could not finish in a half day, and now most Board meetings require a full day or more. He expressed the view that best results are obtained by direct communication rather than through the medium of letters which is one of the reasons why the AIEE is so successful. In conclusion, Mr. Fairman urged that problems should be thought about basically and realistically, particularly in regard to economic affairs, and he stated that he was looking forward to working together with the Sections next year.

THE BANQUET

The banquet which was held on Wednesday evening in the New Ocean House was attended by practically all the members and guests at the meeting. Captain J. M. Worthington and officers of the *USS Rochester*, which was visited by many parties who attended the meeting, were guests of honor.

The principal speaker was Dr. J. R. Killian, Jr., President of Massachusetts Institute of Technology, who gave a most comprehensive address on what is taking place in the field of higher education. Dr. Killian reviewed the enormous increase in student enrollment in the colleges, the expansion in plant facilities necessary to accommodate them, and the methods of financing. He explained that in 1941 there were approximately 155,000 students in the engineering schools; whereas today there are approximately 252,000 which represents a 60 per cent increase. This, in turn, requires an increase in plant facilities of about 60 per cent at an estimated cost of approximately $12,000,000. The expense per student has greatly increased; whereas the income yield from investments have decreased over a period of years.

The number of high school students has increased steadily due to an increase in birth rate following World War I; and the immediate increase in college enrollment has been due to the GI's returning from service. This effect is beginning to decrease and it is expected that there will be approximately a 28 per cent drop in enrollment next year below the figure for this year. The drop in enrollment would continue to decrease particularly if there should be a depression but in the long run it will increase.

Dr. Killian referred to the President's Commission which estimates that in 1960 there will be an enrollment of 4,600,000 in the colleges. This estimate was derived largely by tests given during the war. He believes that the system of junior colleges serves as a good means to take off some of the load as five technicians are required for every engineer. Also, there are many students who would be better off not to take the bachelor of science degree.

With regard to federal subsidies of the colleges, Dr. Killian pointed out that there would be many hazards and grave consequences such as regimentation, centralized control, and so forth. Whether the educational institutions can remain independent is a serious question, and if a first break is to occur, it probably would be in the field of the medical schools.

As one way toward a possible solution to the problem, Dr. Killian suggested that industrial fellowships should be established by the various industries, particularly in the fields where co-operative work is being done, similar to the food foundation which industry is setting up. In conclusion, Dr. Killian explained that American youth cannot have too much education, and at the present time 20 times as many students are attending college in the United States as in England.

Captain J. M. Worthington of the *USS Rochester* expressed the gratitude of the officers and men of his command for the privilege of showing the visiting parties almost every piece of equipment governed or controlled by electricity aboard the heavy cruiser. He described what the *USS Rochester* has done as one of three flag ships of the Mediterranean force, and he explained the role of the heavy cruiser in warfare which is a valuable adjunct to antiaircraft defense.

Vice-President-elect E. W. Davis extended a cordial welcome to members and guests at the banquet. He stated that if the meeting were successful (and it was) it was due to the work of every member of the committee as each one had done everything he was asked to do.

President Lee expressed great appreciation for the wonderful time that everyone was having, and he introduced and thanked personally the chairmen of each of the working committees who had helped to make the meeting so successful. He highly complimented the value of the Navy and said that we never will realize the extent to which the Navy has helped maintain the American way of life. He referred to this branch of the service as the grandest Navy in the world.

ECPD ACCREDITING OF ELECTRICAL ENGINEERING CURRICULA

For the purpose of acquainting members of the Institute and other interested persons with ECPD accrediting of electrical engineering curricula, a session on this subject was held on Monday morning. While it is widely known that accrediting procedures exist, relatively few teachers and practicing engineers are well acquainted with the policies and proccdures. The Committee on Education believed that accrediting is very important in engineering education, especially as a strong influence toward improvement. However if the goal and functioning of accrediting is not clearly understood, it is not attaining its maximum effectiveness. The value of accrediting will be enhanced in proportion as the objectives and procedures are better known to the teachers and engineers concerned with it. To help attain these objectives, the following papers were presented:

"The ECPD Accrediting Program." Donald B. Prentice, President-Emeritus, Rose Polytechnic Institute, and Past Chairman, ECPD Committee on Engineering Schools.

"What the ECPD Visitor Sees." Edward L. Moreland, Executive Vice-President, Massachusetts Institute of Technology, and Senior Partner, Jackson and Moreland, Engineers.

DISTRICT BRANCH PRIZE PAPERS

In accordance with provisions made possible from the Member-for-Life Fund, the following winners of the District Branch Paper Prize Competition in the odd-numbered Districts were represented and the Students made excellent oral presentations:

District 1. "A Visual Aid for the Qualitative Analysis of a Synchronous Motor." Neil I. Burrington

District 3. "Devices for Scoring Pilot Performance." John Katzman, Jr.

District 5. "A New Amplifier for Feedback Computers." Philip N. Hess

District 7. "A Method of Measuring the Viscous Properties of Magnetic Fluids." J. H. Voght and R. H. McKinley

The session was held on Friday morning with E. W. Boehne, Assistant Professor, Massachusetts Institute of Technology, presiding.

President Lee addressed the meeting and spoke from a background enriched from having visited many of the Branches and having had numerous contacts with the Students. He said that the world needs engineers for engineering and electrical engineers for electrical engineering, and advised the Students not to give all of their time to engineering but to develop personal contacts and lasting friendships in life.

President-elect James F. Fairman spoke to the Students and stressed that the value of writing papers was to attain clear expression. If one could get on his feet, and clearly and concisely express his ideas, he has attained an art of communication which has great sales value. The ability to express one's self is a primary asset in the business world.

These thoughts were further exemplified in the talk given by E. W. Davis, General Chairman and Vice-President-elect, who stated that greater opportunities for success lie ahead and that the surface had not yet been scratched. He cautioned against leading too narrow a life and suggested that engineers should be leaders in the political field. Herbert Hoover was cited as a great engineer but without the ability to sell his ideas. It is essential to learn how to talk to people in simple terms; it is necessary to have a good background of history, economics, political philosophy, and so on. Good leaders are proficient in many things. In conclusion Mr. Davis urged the students to be broad and to try to train themselves to be leaders—not followers— in the engineering profession.

ENTERTAINMENT

During the meeting the evenings were given over to entertainment and dancing was enjoyed by many of the members and guests. The President's reception was held on Wednesday evening in the ballroom preceding the banquet. One of the features enjoyed by almost everyone attending the meeting was an old-fashioned barn dance given in true New England style with prizes awarded for costumes.

LADIES' ENTERTAINMENT

In addition to the foregoing events, the Ladies' Entertainment Committee, under the chairmanship of Mrs. F. B. Haeussler, kept the visiting ladies preoccupied during the days with teas; bridge; conducted tours to historical Salem and Marblehead, the North Shore, and Gloucester; a visit to a television station. A handwriting analyst was at one of the bridges, and on another occasion there was a book review.

INSPECTION TRIPS

In addition to the many points of historical interest which New England affords, trips were arranged to the Boston Naval Shipyard, Massachusetts Institute of Technology and Harvard, *WBZ* television, Lynn Telephone Exchange, the Mystic Station of the Boston Edison Company, and the Lynn works of the General Electric Company. Friday afternoon was devoted to a special outing for Students which began with a luncheon as guests of the General Electric Company at the Thompson Club. The wives of Students were invited to attend.

During the first four days of the meeting many groups took advantage of the excellent trip to the heavy cruiser *USS Rochester*. Members and guests were conducted through the various parts of the cruiser by the officers who explained the operation of the electric equipment from the turbine rooms and fire rooms up to and including the bridge, with its variety of navigational instruments and various kinds of radar equipment.

MERSHON GOLF AND TENNIS COMPETITION

The tournament for the Mershon Golf Trophy which was played during the week was won by C. B. Oler, Annapolis, Md., with P. W. Howlett of Montreal, Quebec, Canada, the runner-up. Daily low net scores were obtained by the following: Monday, S. P. Blakemann; Tuesday, K. M. Smith, Chicago; Wednesday, P. W. Howlett, Montreal; Thursday, H. P. Turner, Providence, and F. S. Black, New York.

Competition for the Mershon Tennis Trophy was won by L. T. Akeley of Lynn, with the runner-up John H. Simpson of Canada. The winners of the doubles were L. T. Akeley of Lynn and T. Henry, Jr., of Toronto.

COMMITTEES

Members of the Summer General Meeting Committee, which helped to make the meeting highly successful with well-planned arrangements and smoothly-conducted affairs, were as follows:

E. W. Davis, *General Chairman;* M. A. Princi, *Vice-Chairman;* R. E. Muehlig, *Secretary-Treasurer;* R. G. Porter; R. G. Slauer; F. P. Taugher

The chairmen of subcommittees were

Registration, A. L. O'Banion; *Publicity,* H. B. McIntyre; *Entertainment and Banquet,* G. J. Crowdes; *Transportation,* A. B. Whitehouse; *Hotels,* R. G. Connors; *Inspection,* J. R. Macintyre; *Finance,* C. A. Corney; *Students,* E. W. Boehne; *Meetings and Papers,* J. O'R. Coleman; *Hospitality,* F. S. Bacon, Jr.; *Ladies,* Mrs. F. B. Haeussler; *Sports,* A. F. Lukens

Wide Range of Topics Covered at Summer Meeting Technical Sessions

A wide range of subjects was covered in the 30 technical sessions held during the AIEE Summer General Meeting, at Swampscott, Mass., June 20–24, 1949. A detailed program of the sessions appeared in the June issue of *Electrical Engineering* (*EE, June '49, pp 538–40*).

POWER

In the power field sessions were conducted on switchgear, insulated conductors, substations, carrier current, transformers, transmission and distribution and system engineering, and primary network systems. In the switchgear session one technical program paper and three conference papers were presented. The technical paper covered an analytical method of co-ordinating reclosures with series fuses and how field tests have substantiated the method (49-128). The conference papers included information on metalclad switchgear production problems, selective tripping of low-voltage air circuit breakers for power station auxiliaries, and a guide for application of low-voltage air circuit breakers.

The insulated conductor papers covered the more recent types of high-voltage cable and associated structures. Topics included transformer manholes and vaults (49-133), temperature rise of cables in duct banks (49-134), a-c resistance of segmental cables in steel pipe (49-135), 69-kv pipe-type cable circuits in Philadelphia (49-136), and recent developments and trends in high-voltage cable transmission. This last-named paper is scheduled for early publication in *Electrical Engineering*.

The substations session included papers on aluminum alloy substation structures, application of the "multiplex" scheme at urban distribution substations in Baltimore, Md., protection of transformers by automatic grounding and air break switches (49-143), and a 2-signal supervisory control system (49-144).

Two technical program papers and four conference-type papers were featured at the carrier current session. Carrier current applications on a 132-kv line composed of underground and overhead conductors including loss measurement techniques (49-150), and power line carrier for relaying and joint usage summarizing standard practices and emphasizing points of uncertainty and controversy (49-151) were treated in the two technical program papers. The four conference papers discussed various phases of microwave equipment and applications in the power industry.

Two transformer sessions which included eight technical program papers and two conference papers were held during the meeting. Subjects included economic loading of a transformer system (49-188), transformer heating under short-circuit conditions (49-189), reactor rating standardization (49-190), audio noise problems (49-191), use of thyrite in power transformers (49-192), temperature and insulation protection (49-193), a small high-voltage bushing for high altitude (49-194), and insulation co-ordination of oil insulated transformers (49-195) in the technical paper group. The conference papers covered proposed AIEE Transformer Standards and British standardization.

The transmission and distribution and system engineering session consisted of seven papers. The technical program papers included such subjects as a metropolitan 66-kv subtransmission plan (49-172), steel and wood transmission line performance (49-173), stationary networks and transmission lines along uniformly rotating reference frames (49-174), overcurrent investigation on a rural distribution system (49-175), lightning measurement techniques (49-61), and short-circuit currents and recovery voltages on rural distribution systems (49-177). A paper on planned development of a power system also was presented.

The primary network systems session included four papers covering various considerations on primary networks of the Oklahoma Gas and Electric Company (49-178), the Dusquesne Light Company (49-179), the Potomac Electric Power Company (49-180), and the Boston Edison Company.

INDUSTRY

In the industry group, sessions were held on electric welding, industrial control and servomechanisms, electric heating, and storage batteries. In the welding session four papers were presented. Topics included an arc metal transfer analyzer, a study of arcs between moving electrodes, electronic resistance welding control timing pattern, and a paper pointing out the advantages of low-frequency welding converters.

Five papers were featured at the industrial control and servomechanisms session. Four of these were technical program papers dealing with dynamic braking control (49-138), adjustable speed drive (49-199), instrument inaccuracies in feedback systems (49-197), and servomechanism steady state and transient performance (49-196). The conference paper covered magnetic-fluid clutch servomechanism systems.

Various problems in electric heating were discussed in the five papers presented at this session. Among the subjects discussed were reduction of radio interference from radio-frequency heating equipment (49-182), high-temperature ceramic insulations, electric steam boilers and water heaters, temperature measurement in infrared heating processes, and measurement of low-intensity fields at ultrahigh frequencies.

The battery session featured three conference-type papers covering railway battery maintenance, prolonging battery life, and dry disk rectifier design and applications.

COMMUNICATIONS AND SCIENCE

In the communications and science field sessions were conducted on instruments and measurements, nucleonics, relay switching circuits, radio telemeter instrumentation, wide-band communication, computing devices, basic sciences, semiconductors, statistical applications, magnetic amplifiers, and applied mathematics.

A number of interesting devices and techniques were discussed in the two instruments and measuring sessions and the radio telemeter instrumentation session. Among the topics covered were measuring dielectric loss at high frequencies (49-130), measuring stability of the welding arc (49-131), a wide-band d-c amplifier (49-132), an automatic range-adjusting radiosonde recorder (49-152), a thermal converter for telemetering (49-159), heat flow ratio in thermal demand meter design (49-160), an expanded scale a-c voltmeter (49-161), unusual cathode-

ray oscilloscope applications, impulse measurements using repeated structure networks, meteorological telemetering, pulse width modulation and frequency modulation telemetering systems, a new instrument mechanism, and ergmeter considerations.

The nucleonics session consisted of four conference-type papers describing various instruments used in this field. Included were health physics instrumentation, electronic aids to the nuclear physicist, radioactive-type thickness gauges, and scintillation counters.

The relay switching session consisted of five technical program papers covering the fundamental and functional design of relay switching circuits. The papers evoked a great deal of interest because they were so arranged as to give the audience a good introduction to the subject and then applications of the principles were cited. These circuits, though mostly used in telephone work also are being widely applied in other fields such as power station switching. Topics covered the logic of relay circuits (49-145), sequential aspects of relay circuits (49-146), relay "trees" and symmetric circuits (49-147), counting with relays (49-148), and codes and translations (49-149).

The two semiconductor sessions consisted of papers that cited the present status of what is known in this field. The subject was treated in four parts, the nature of conductivity in semiconductors, photo effects in semiconductors, semiconductor rectifiers, and the transistor. Though all the papers were conference-type papers and not available, a series of articles based on these sessions is being prepared for early publication in *Electrical Engineering*.

The statistical applications session included such topics as quality control, diagnosis with diagrams, tests of significance, and saving time in testing life of lamps (49-187). This last paper has appeared in *Electrical Engineering* (*EE, Jul '49, pp 716–20*).

The applied mathematics session was devoted to a discussion of the operational calculus and various transform methods. The history, applications, and correlation of the methods of operational calculus were discussed as well as a derivation of Heaviside's operational calculus based on the generalized functions of Schwartz (49-185).

In the basic science session a variety of subjects were discussed. These included calculation of magnetic field components of circular filaments (49-167), the moving coil flux meter (49-168), nonharmonic oscillations caused by magnetic saturation (49-170), and symbolic treatment of sinusoids. The last paper has appeared in *Electrical Engineering* (*EE, Jul '49, pp 561–5*).

A number of interesting computers were described at the computer session. These were a Fourier coefficient harmonic analyzer (49-163), an a-c network analyzer (49-164), and the model *VI* Bell computer. In addition, a paper also was presented on the use of California Institute of Technology's electric analog computer in nonlinear and servomechanism problems (49-165), and various transformations useful in constructing electrical analogs of linear vibration problems (49-166) were included in a paper presented by title only.

In the magnetic amplifier and d-c saturated reactor session included such topics as the amplistat (see pages 663-77 of this issue), self-saturation in magnetic amplifiers (49-140), analysis of magnetic amplifiers with feedback (49-139), transients in magnetic amplifiers, and pulse transformer design (49-198).

Four papers comprised the wide-band communication media sessions. These described an alarm and control system for remote control of coaxial cable stations (49-155), power supplies for coaxial systems (49-156) and microwave relay systems (49-157), and a microwave communication relay system (49-158).

GENERAL APPLICATIONS

Three sessions were held on general applications of electric apparatus. These included land transportation and lighting, infrared radiation, and pulp and paper discussions. The land transportation paper discussed diesel-electric switching locomotives in industrial plants (49-176), and the lighting subject dealt with measurement of erythermal energy (49-186). The five conference papers in the infrared session covered such phases of the subject as the basic optics, various types of infrared detectors, the military needs found in this field, and industrial applications of infrared spectroscopy.

The pulp and paper session featured two subcommittee reports, one on electric equipment for paper mill supercalenders and the other on electric equipment for paper mill winders.

PUBLICATION

In general none of the conference papers presented at the meeting are available for the Institute. However, brief authors' digests of most of the conference papers presented appear in this issue (pages 697-91). The technical program papers (those indicated by numbers in parentheses) presented at the meeting are available and may be ordered as AIEE *Proceedings* sections on the standard order form which appeared in the advertising section of last month's issue (*EE, Jul '49, pp 47A and 48A*). In addition, one-page digests of the technical program papers are scheduled for early publication in *Electrical Engineering*.

AIEE Board of Directors Holds Regular Meeting in Swampscott, Mass.

A regular meeting of the AIEE Board of Directors was held in the New Ocean House, Swampscott, Mass., Thursday, June 23 1949, during the Summer General Meeting.

President Lee reported briefly upon his recent trips, and some of the Vice-Presidents mentioned occasions on which they had represented the Institute. The minutes of the meeting of the Board of Directors held in Dallas, Tex., April 20, 1949, were approved.

Actions of the Executive Committee, as of May 31, 1949, on membership applications were reported and confirmed as follows: 15 applicants transferred to the grade of Fellow; 30 applicants transferred, 55 applicants elected, and 4 applicants re-elected to the grade of Member; 860 applicants elected, and 12 applicants re-elected to the grade of Associate; 828 Student members enrolled.

Recommendations on membership applications adopted by the Board of Examiners at meetings on April 21, May 19, June 7, and June 16, 1949, were reported and approved. Upon recommendation of the Board of Examiners, 29 applicants were elected to the grade of Member, 163 applicants were elected and 4 applicants were re-elected to the grade of Associate, and 393 Student members were enrolled.

The report on uniform grades of membership, prepared by a conference of representatives of the member societies held under the auspices of Engineers Council for Professional Development, was accepted in principle, and is to receive further consideration at the August meeting.

FINANCES

Monthly expenditures were reported by Chairman Yerkes of the Finance Committee and confirmed by the Directors, as follows: May, $65,964.44; and June, $65,215.02.

Mr. Yerkes reported that, for the portion of the budget year October 1–June 16, the receipts were 76.4 per cent of the estimated income for the year, as compared with 73.5 per cent (of actual) for the same period last year, and the disbursements to June 30 amounted to 75.4 per cent, as compared with 73.4 per cent last year.

An advance of $200 was granted for a Joint AIEE-Institute of Radio Engineers Conference on Electronic Instrumentation in Nucleonics and Medicine, to be held in New York, N. Y., October 31–November 2, 1949. The conference is expected to be self-liquidating.

The Finance Committee presented a summary of its studies of 5-year estimates of income and expenses submitted by a number of Institute committees. It concluded that, upon the assumptions of no violent changes in underlying conditions, or in Institute policy, no immediate necessity for an increase in dues is indicated.

PLANNING AND CO-ORDINATION

Upon recommendation of the Committee on Planning and Co-ordination, the following approvals were granted: Dates of April 12–14, 1951, for a Southern District Meeting in Miami, Fla.; the dates of May 2–4, 1951, for a North Eastern District meeting in Syracuse, N. Y.; scope of the newly established Committee on Metallic Rectifiers; scopes of the seven committees in the newly established Communication Group; establishment of an AIEE-IRE Committee on Jointly Sponsored Annual Electronics Symposium; establishment of a new committee in the field of servomechaniams; Manual for Special Technical Conferences; revised rules for prizes for technical papers; and a plan for the administration of the Volta Scholarship Fund.

SECTIONS

The following actions were taken upon recommendation of the Sections Committee:

Muscle Shoals Section made a Subsection of the East Tennessee Section; Western Virginia Section authorized; Ottawa Section authorized; Hardin County, Ohio, transferred from the territory of the Columbus Section to that of the Dayton Section; several counties in Florida transferred from the territory of the Florida Section to that of the Alabama Section; territory of Puerto Rico removed from New York Section territory; speakers lists for Sections discontinued.

STUDENT ACTIVITIES

The report of the AIEE-Institute of Radio Engineers Subcommittee on Joint Student Branches and the model constitution accompanying it were approved, as recently revised. A suggestion that better coordination be established between the Committee on Student Branches and the chairmen of the District Committees on Student Activities was approved in principle, and referred to the Committee on Constitution and Bylaws for incorporation in Section 84 of the Bylaws.

An invitation to appoint a representative to discuss Student Chapters with representatives of other engineering societies was accepted, and Professor F. O. McMillan, incoming chairman of the Committee on Student Branches, was appointed.

OTHER MATTERS

H. H. Henline was reappointed Secretary of the Institute for the administration year beginning August 1, 1949.

The annual report of the Board of Directors for the fiscal year ended April 30, 1949, was approved, subject to any corrections submitted not later than July 7.

An invitation from Engineers Joint Council to designate a representative as a member of an exploratory group for a discussion of the possibility of stimulating further unity in the engineering profession, and possible forms of organization to bring this about, was accepted, and Titus G. LeClair was designated as AIEE representative.

Other activities of EJC were reported and discussed.

The North Eastern District Executive Committee invited the Board of Directors to hold a meeting in Providence, R. I., next April, during the District meeting.

Present at the meeting were

President—Everett S. Lee, Schenectady, N. Y.
Past Presidents—J. Elmer Housley, Alcoa, Tenn.; B. D. Hull, Dallas, Tex.

Vice-Presidents—J. H. Berry, Norfolk, Va.; G. W. Bower, Haddonfield, N. J.; J. L. Callahan, New York, N. Y.; D. I. Cone, San Francisco, Calif.; I. M. Ellestad, Omaha, Nebr.; G. N. Pingree, Dallas, Tex.; E. W. Seeger, Milwaukee, Wis.; Victor Siegfried, Worcester, Mass.

Directors—W. L. Everitt, Urbana, Ill.; J. F. Fairman, New York, N. Y.; C. W. Fick, Cleveland, Ohio; J. M. Flanigen, Atlanta, Ga.; R. T. Henry, Buffalo, N. Y.; M. D. Hooven, Newark, N. J.; F. O. McMillan, Corvallis, Oreg.; A. C. Monteith, East Pittsburgh, Pa.; J. R. North, Jackson, Mich.; Elgin B. Robertson, Dallas, Tex.; Walter C. Smith, Palo Alto, Calif.; E. P. Yerkes, Philadelphia, Pa.

Secretary—H. H. Henline, New York, N. Y.

By invitation:

Past President—A. M. MacCutcheon, Shaker Heights, Ohio

Incoming Officers—W. C. DuVall, Boulder, Colo.; A. H. Frampton, Toronto, Ontario, Canada; R. A. Hopkins, Los Angeles, Calif.; W. J. Seeley, Durham, N. C.; C. G. Veinott, Lima, Ohio; E. W. Davis, Cambridge, Mass., *part time*.

South Texas Section Meets at Buchanan Dam

A recent weekend meeting of the AIEE South Texas Section was held at Buchanan Dam, which is a part of the hydroelectric development of the Lower Colorado River Authority. In addition to touring the mile-long dam, those who attended the meeting witnessed the progress being made on the new pump storage installation and heard technical talks concerning this installation. Also featured was the presentation of their prize winning papers by two University of Texas Student members.

Officers of the South Texas Section are M. E. Noster, Chairman; L. L. Antes, Vice-Chairman; and A. C. Alberti, Secretary-Treasurer.

North Central District Holds Student Branch Conference

The South Dakota School of Mines and Technology was host to a 2-day Student Branch conference of the North Central District, May 6–7, 1949. The following papers were presented by the students.

"Impulse Voltage Generation," C. D. Finnel, Colorado Agricultural and Mechanical College

"The Merits of Power Factor Control," R. W. Schroeder, Colorado Agricultural and Mechanical College

"The Magnetic Fluid Clutch," H. W. Van Gerpen, South Dakota School of Mines and Technology

"A Proposed Modification of the Synchronous Reactor," Robert Richardson and Robert Shore, University of Colorado

"Prevention of Noncyclic Lamp Flicker," M. G. Kroger, University of Nebraska

"Power Distribution," Howard S. Smith, University of Denver

"Studio Audio Equipment," R. L. Libby, University of Wyoming

"Current Calculation of Y-Delta Distribution Transformers," C. M. Theiss and W. W. Braudt, University of Colorado

"Airplane Radio Blackout," Galen Maurer, University of Wyoming

"A Report of Single-Sideband Radio Telephony," D. C. Bakeman, South Dakota School of Mines and Technology

Professor J. O. Kammerman, Chairman of the District Committee on Student Activities, presided over the first session, and Chairman A. L. Jones of the South Dakota School of Mines and Technology Branch presided over the second session.

In the evening a banquet was held at which Vice-President Ellestad announced the winners of the Student Paper competition. The District Branch Competition prize, consisting of a certificate and $25, was awarded to H. W. Van Gerpen. The second and third prizes, consisting of $15 and $10 respectively, were contributed by the Denver and Nebraska Sections. The second prize was awarded to D. C. Bakeman, and the third prize to C. D. Finnel.

The banquet was addressed by I. M. Ellestad, Vice-President of the North Central District, and Dr. Warren Wilson, President of the South Dakota School of Mines and Technology. Vice-President Ellestad spoke on the topic, "The Best Is Yet to Be," and drew attention to the rapid rate of progress with a six-fold increase in the amount of electric power produced in the United States, and about a four-fold increase in the number of telephones during the last 30 years. Dr. Wilson spoke of the "Education of the Engineer," and outlined recent changes which had taken place in the engineering field, as well as ways in which to attain professional recognition.

A business meeting of Branch Counselors and incoming Branch Chairmen was held on the next day followed by a trip to the Mt. Rushmore Memorial. Other short trips were taken by the students during the meeting to a nearby heat pump installation at the Black Hills Power Company Building, and to the laboratories of the South Dakota School of Mines and Technology.

COMMITTEE NOTES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees. It will include brief news reports of committee activities and proposed plans for such projects as special technical conferences and sessions at general meetings. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

Manual Available on Conducting Special Technical Conferences

The AIEE Board of Directors at its meeting in Swampscott, Mass., approved a manual on policy and procedure for conducting AIEE "Special Technical Conferences." This manual is the result of extensive study and discussion of the subject conducted by the Technical Activities Subcommittee and experience gained by committees in running the past ten conferences.

Topics covered in the manual include such items as policy, administration, finance, conference committee organization, reports, and publication of conference proceedings.

As these special technical conferences are sponsored by the technical committees or subcommittees jointly with the local Sections, it is important that committees contemplating such conferences obtain a copy of the manual for their guidance. Requests should be forwarded to R. S. Gardner, AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

Power Group

Committee on Substations. (*G. S. Lunge, Chairman; R. C. Ericson, Vice-Chairman; Marino Fraresso, Secretary.*) This committee, formerly the "Automatic Stations Committee," has completed organization of its subcommittees and working groups to cover the greatly expanded scope of this technical committee. The main committee has assigned the following projects for study and action by the subcommittees concerned.

Automatic and Supervisory Control Subcommittee: Projects relating to investigating the reliability of supervisory and automatic control for substations, and also revision of American Standard C37.2–1945 covering such equipment.

Transmission Substations Subcommittee and Distribution and Conversion Substations Subcommittee:

Projects dealing with the relative merits and standardization possibilities of the one-line diagram connections and structural design of the substations falling within their jurisdiction, also the problem of safety considerations in substation design, station lighting practices, and the problem of station auxiliary power supply for substations.

Distribution and Conversion Substations Subcommittee: Projects covering the relative merits of circuit breakers versus reclosing fuses for small distribution substations and the choice of bus regulation versus feeder regulation for distribution substations.

Working Group on Device Function Numbers has prepared and recently circulated a questionnaire regarding the adequacy of the present standard device numbers as established in American Standard C37.2-1945.

Working Group on Rectifier Switchgear, which is responsible for treatment of all matters pertaining to the design, construction, and application of switching devices, instrumentation, protective and functioning relays for electronic power converters, already has prepared a conference paper on electronic power rectifier protection that was presented at the January Winter General Meeting in New York, N. Y. This paper was followed by a formal paper of similar scope presented at the Summer General Meeting in June 1949.

Another working group has been organized on the subject of substation grounding practice. This group is responsible for investigation and study of substation grounding system design and testing practices, including consideration of the relative merits of galvanized iron versus copper electrodes. This group includes representation from two of the subcommittees of the Committee on Protective Devices.

Industry Group

Committee on Industrial Power Systems. (*J. S. Gault, Chairman; H. G. Barnett, Vice-Chairman; M. C. Mapes, Secretary.*) During the past year this committee sponsored two sessions, one on industrial power distribution systems and the other on chemical and petroleum industry problems. The committee has three subcommittees, all of which have been active. These are the Subcommittee on Wiring Design for Commercial Building, Subcommittee on Revision of the Red Book on Industrial Power Distribution Systems, and Subcommittee on Transformer Ratios. The latter subcommittee has not been as active, as it was appointed mainly as a group to watch developments in the Edison Electric Institute–National Electrical Manufacturers Association transformer voltage standardization program.

Committee on Mining and Metal Industry. (*F. W. Cramer, Chairman; T. B. Montgomery, Vice-Chairman; A. C. Muir, Secretary.*) The Committee on Mining and Metal Industry was organized to present information on electrical processes, developments, or power requirements of the various operations in the mining and metal industries.

Several sessions on the coal mining and steel industries have been sponsored, also wire drawing and ore beneficiation, all of which have been well attended.

At the Fall General Meeting in Cincinnati there will be two sessions on coal mining problems that have been planned in co-operation with the American Mining Congress; a third session, which should be of interest to many, will be on the aluminum industry. This latter represents a new idea on industry meetings in that The Aluminum Association is obtaining the authors and their papers to give a co-ordinated session on interesting phases of their industry.

The subject of ore beneficiation will be further developed at a future meeting. This concerns the making of concentrates from the low grade iron ores, in which the ores are crushed and finely ground to make separation of the iron oxides possible. The process requires large blocks of electric power and will result in power development programs in the Michigan–Minnesota ore fields.

In future meetings in the Midwest and on the Pacific Coast, industry sessions on the copper producing processes and on the rapidly expanding western steel industry will be planned; also, bauxite mining and preparation, which concerns the aluminum industry.

It will require several years for this committee to cover the scope of work, but each year useful and interesting information will be presented on processes and electrical developments in mining and metals.

Science and Electronics Group

Committee on Nucleonics. (*J. J. Smith, Chairman; W. F. Davidson, Vice-Chairman; R. C. Bergvall, Secretary.*) The Nucleonics Committee as part of its program on disseminating information pertinent to its field sponsored a conference session at the Summer General Meeting at Swampscott. This session, which was handled through the Joint Subcommittee on Nucleonic Instruments, included the following four papers: "Problems in Health Physics Instrumentation," Samuel Levin, Massachusetts Institute of Technology; "Some Electronic Aids to the Nuclear Physicist," Emil de Agazio, Massachusetts Institute of Technology; "Thickness Gauges in Industry Employing Radioactivity," J. R. Carlin, Tracerlab, Inc.; "Scintillation Counters," William G. Cross, Harvard University. This session was the fifth to be sponsored during the Institute year with similar sessions having been held through the efforts of the several subcommittees at the Pacific General Meeting in Spokane, Wash.; the Middle Eastern District Meeting in Washington, D. C.; the Winter General Meeting in New York; and the South West District Meeting in Dallas, Tex. It is expected that sponsorship of nucleonic sessions will be a continuing practice.

With the completion of publication of the series of 11 articles on nucleonics which the committee sponsored for *Electrical Engineering* during the past year, the entire series was issued in booklet form under the title "Elements of Nucleonics for Engineers." This publication is available at Institute headquarters.

The committee has participated in setting up a joint effort under the National Research Council toward the preparation of a glossary of nuclear energy terms. This effort is being carried forward in co-operation with a large number of other participating societies and drafts of the various sections are being reviewed.

In view of the success of the AIEE/Institute of Radio Engineers Joint Conference on Electronic Instruments for Nucleonics and Medicine which was held in New York, N. Y., November 29–December 1, 1948, plans are under way to hold a second such conference this year on October 31–November 2. The first conference, which was a joint effort with the Institute of Radio Engineers, was sponsored in AIEE by the Nucleonics Committee in co-operation with the Electronics Committee's Subcommittee on Electronic Aids to Medicine. This same arrangement is being followed in the present plans. A Joint Planning Committee has been set up with representatives of both the AIEE and the Institute of Radio Engineers and work is well along on the program.

General Applications Group

Joint Subcommittee on Carbon Brushes. (*V. P. Hessler, Chairman.*) The AIEE Joint Subcommittee on Carbon Brushes is a joint subcommittee of the Rotating Machinery and Air Transportation Committees. The subcommittee was given the assignment of preparing a test code for electric brushes and of encouraging the preparation and presentation of papers concerning the operation of sliding contacts.

The brush committee co-operated with the D-C Machines Subcommittee in gathering material for a sequence of sessions at the 1949 Winter General Meeting. The sessions included papers on commutation and on the theory and operation of the sliding contact. A progress report on an AIEE Test Code for Electric Brushes also was presented at the Winter General Meeting. The following indicates the objectives considered by the committee in its work on the preparation of a test code:

> It is the purpose of this brush test code to define procedures for measuring the physical properties of electric brush materials, for determining the quality of brush assemblies, and to test the performance of brushes as part of the sliding contact. Since some of the tests are empirical, and since the test results vary with many test conditions, it is desirable to standardize test procedures to reduce these variables to a minimum. Test data based on standard procedure should facilitate comparison of various brush grades and assist designers in the selection of the most satisfactory brush for the machine application and operating condition involved.

The major divisions of the report are Purpose, Measurements on Material Specimens, Tests on Brush Assemblies, Sliding Contact Operating Characteristics, Life Tests, Commutating Ability Tests, and Altitude Tests. The statements of the tests for measurement of material specimens is reasonably complete and include tests on specific resistance, density, porosity, hardness, strength, and percentage ash. The tests are made primarily for the purpose of production controls and in general do not provide a direct means of determining operating characteristics. The tests on brush assemblies include shunt millivolt drop and vibration tests on shunt connections. These tests are not described in the report but it is expected that satisfactory procedures will be agreed upon shortly. The remaining sections are projected and some time may elapse before a standard procedure can be stated to the satisfaction of all concerned.

The subcommittee has been collaborating unofficially with the Carbon Section of the National Electrical Manufacturers Association in the preparation of this material. In January the Carbon Section of NEMA asked that the subcommittee work jointly with them in the preparation of the code. The committee concurred in this suggestion and approval by the Standards Committee for

this joint activity now has been obtained. It is expected that the developmental work required to complete the test code will move forward effectively with the two interested groups working together simultaneously on the project.

Subcommittee on Aircraft Control, Protective Devices, and Cable of the Air Transportation Committee. (*R. J. Lusk, Chairman.*) The subcommittee has completed a proposed Test Code for Aircraft D-C Circuit-Interrupting Devices, and a Working Group on Voltage Regulators (*Chairman*—R. E. Lloyd, Chicago, Ill.) sponsored by the subcommittee soon will complete a proposed Test Code for Aircraft D-C Carbon-Pile Voltage Regulators. These test codes should aid in promoting standard test methods for aircraft contactors, circuit breakers, relays, and voltage regulators, and in establishing a standard base for application of these devices. At present, the subcommittee has under consideration the preparation of recommended practices for installation of electric cable in aircraft and application of circuit protective devices to aircraft electric circuits, and is cooperating with the Subcommittee on Aircraft Electric Systems in revising the Aircraft Electric Systems Guide.

AIEE PERSONALITIES.....

R. H. Manson (A '02, F '44), president of the Stromberg-Carlson Company, Rochester, N. Y., since 1945, has retired to become chairman of the board. Joining Stromberg-Carlson in 1916, he was elected a director four years later, vice-president in charge of engineering in 1924, and general manager in 1940. An alumnus of the University of Maine, class of 1898, he received a doctor of engineering degree in 1933. Holder of more than 100 patents in the field of electronic communications, he has been a member of the AIEE communications committee, 1923–31. In addition, he served on the United States National Committee of the International Electrotechnical Commission, 1927–30, and the Liaison Committee on Aeronautic Radio Research, Department of Commerce, 1930–33. Other organizations to which Manson belongs are: the Institute of Radio Engineers; the Rochester Engineering Society; the Acoustical Society of America; the Radio Club of America; the Radio Manufacturers Association; the Telephone Pioneers of America; and the Independent Pioneer Telephone Association.

J. G. Reid (A '46, M '48), until recently, chief engineer, electronic instrumentation laboratory, National Bureau of Standards, Washington, D. C., has been named chief of the NBS engineering electronics laboratory. One of the senior scientists in the bureau's radio proximity-fuse program during World War II, he will direct research on electronic instrumentation, miniaturization, printed circuits, and electronic-circuit components and standards. In 1937, four years after he received his doctorate from the University of Arkansas, he joined the National Bureau of Standards, as a member of the heat and power division. From 1941 to 1943, he was a chief engineer on the Bureau's uranium project, following which period he was assigned to proximity-fuse work. In his last position of chief engineer, he concentrated on special instrument systems utilized by the Navy and Treasury Department. Reid is a member of the American Physical Society.

F. A. Cowan (M '29, F '45), formerly transmission engineer, operating and engineering department, has been transferred to the American Telephone and Telegraph Company's long lines department. His new designation in the firm's New York, N. Y. office is assistant engineer. Joining the long lines department in 1919 in Atlanta, Ga., Cowan came to New York three years later. Taking over Cowan's old job is **C. M. Mapes** (M '40). **H. I. Romes** (A '41, M '47) is slated to fill Mapes former position of plant extension engineer. An active AIEE member, some of the committees on which Cowan has served are: communication, 1941–47; planning and coordination, 1943–45; award of Institute prizes, 1943–46 (chairman, 1943–45); communication and science co-ordinating, 1947–48; and technical program, 1941–49 (chairman, 1943–45). Romnes has belonged to the AIEE communications committee for the last four years.

R. T. Stafford (A '18, F '46), assistant to the executive vice-president, Allis-Chalmers Manufacturing Company, New York, N. Y., has been awarded the 50-Year Certificate by the National Electrical Manufacturers Association, for having completed a half century of service in the electrical industry. Beginning his career in 1898 with the Buffalo Railway Company (now the International Traction Company), he later worked for the Manhattan Elevated Railway Company, New York, N. Y. Joining Allis-Chalmers in 1905, he did sales engineering work and was manager of the company's Pittsburgh, Pa., transformer division. In 1947, he was named to his present position. Stafford has contributed to many developments in the transformer industry, one of these being the divided protection gap for pole-type distribution transformers.

C. A. Mabey (F '48), formerly director of research for the Bristol Company, Waterbury, Conn., has been appointed chief of the engineering electronics laboratory at the National Bureau of Standards, Washington, D. C. Experienced in the microwave, ultrashort radio wave, humidity-measurement, and automatic-control-apparatus fields, Mabey, in his new position, will supervise electronic miniaturization, circuits, and processes. A 1929 graduate of Harvard College, he has done graduate work at his alma mater and Massachusetts Institute of Technology. Mabey is a member of the American Physical Society, the Instrument Society of America, the Institute of Radio Engineers, and the American Society of Mechanical Engineers.

C. K. Duff (A '28, M '41), former meter engineer, the Hydro-Electric Power Commission of Ontario, Toronto, Canada, has been appointed system control engineer with the same organization. Having served for over 14 years in the commission's operations division, where he had been a consultant on instrument transformers, telemetering, and load control, Duff is a 1918 graduate in electrical engineering of the University of Toronto. A member of the Association of the Professional Engineers of Ontario, he is serving at present on the AIEE joint subcommittee on telemetering and supervisory control and the AIEE instruments and measurements committee.

A. Srinivasan (A '47) has been appointed professor of electrical engineering at the College of Engineering, Anantapur, Madras, India. After receiving his master's degree from the University of Madras, he was sent to the United States by the government of Madras, India for further training. During his 2-year stay in this country, he was granted a master's degree by the Illinois Institute of Technology, and later worked as a special graduate trainee in the development section of the Allis-Chalmers Manufacturing Company, Pittsburgh, Pa. The coauthor of two papers presented before AIEE meetings, he is a member of Sigma Xi and Eta Kappa Nu.

H. L. Caldwell (A '07, F '20), electrical engineer in charge of operation, has retired from the Water and Power Department, Los Angeles, Calif., after a quarter century of service with the organization. Educated at the University of Illinois and the Armour Institute of Chicago, Caldwell joined the Water and Power Department in 1923. Previously, he had been employed by the North Shore Electric Company, the Chicago City Railway Company, and the Public Service Company, all in Chicago, Ill. Caldwell served on the AIEE membership committee, 1941–42.

L. G. Pacent (M '18, F '30), president and technical director, Pacent Engineering Corporation, New York, N. Y., has been appointed a member of the American Standards Association Sectional Committee on Acoustical Measurements and Terminology, as a representative of the AIEE. He has been associated with the electronic industry since 1912. Also, Mr. Pacent recently was made consulting engineer for Plessey International Limited, Ilford, Essex, England. A member of the Communication Committee for the last ten years, he is serving at present on the Board of Examiners.

J. Z. Linsenmeyer (A '43) has been appointed manager of mining, petroleum, and chemical engineering for the Westinghouse Electric Corporation, East Pittsburgh, Pa. A 1937 alumnus of Lehigh University, he completed the Westinghouse student course, subsequently serving as an industry engineer in the general mill section and the mining,

petroleum, and chemical section. He is a member of the American Society of Mechanical Engineers.

L. A. Morphey (A '26) has been promoted to superintendent of power, with responsibility for the operation and maintenance of production, transmission, and substation facilities, for the Pacific Power and Light Company, Portland, Oreg. He had been with the staff of the former Northwestern Electric Company from 1922 until being transferred to the power department of the Pacific Power and Light Company in 1941.

C. N. Richardson (A '19), associated for two years with Mathieson Chemical Corporation, and previously with the Fixed Nitrogen Research Laboratory, has opened a consulting office at Youngstown, N. Y., in the Niagara Falls area. Richardson's specialties include mercury-cathode electrolytic cells, electric furnaces, and high-tension electric discharges.

Irven Travis (M '46), a professor on the faculty, and formerly supervisor of research, the Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia, has been named director of research at the Burroughs Adding Machine Company, Detroit, Mich. Dr. Travis, while continuing as professor, will assume direction of the company's new research laboratory.

J. T. Kimball (A '18), formerly assistant to the president, Central Arizona Light and Power Company, Phoenix, Ariz., has been elected vice-president of that organization. Kimball joined the firm in 1946 as manager of research and development. Previously, he had been associated with the Mississippi Power and Light Company for 12 years.

A. N. Prentice (M '45) has been named assistant to the vice-president and general manager of the Ohio Power Company, Canton. With the company since 1928, he was appointed assistant general meter superintendent in 1934, head of the general engineering department six years later, and managerial assistant in the office of the vice-president in 1946.

S. W. Upham (A '41) has been named sales manager in the Government division of the General Electric Company, Syracuse, N. Y. Head of the Army section of the division since 1945, he now will be responsible for the sale of all electronic equipment to the United States Army. With General Electric since 1941, he also has worked in the Government division's Navy section.

J. M. Nelson (M '43), until recently in charge of relay sales, has become manager of meter sales at the Newark, N. J., branch of the Westinghouse Electric Corporation. Joining the company in 1926, he has spent 22 years in the meter division's sales department.

R. B. Tandy (A '49), formerly synchronous design engineer, has been promoted to the position of manager of the large apparatus sales division of the Ideal Electric and Manufacturing Company, Mansfield, Ohio. Prior to joining the company last year, Tandy was an instructor of electrical design at the University of Michigan, Ann Arbor.

H. C. Steiner (A '32, M '44), formerly section engineer for power ignitron tubes, has been made designing engineer for industrial tubes, industrial and transmitting tube division the General Electric Company, Schenectady, N. Y. He is serving on the Electronic Power Converters and Electronics Committees.

L. R. Patterson (A '30, M '41), formerly staff engineer, electric operations, has been named superintendent, electric system planning, with the Public Service Company of Colorado, Denver. He joined the organization in 1923 as a draftsman in the electric distribution engineering department. He served on the Sections Committee, 1948–49.

S. C. Spielman (A '48), formerly assistant chief engineer, has been made chief engineer on television receiver development at the Philco Corporation, Philadelphia, Pa.

OBITUARY

Lee S. Washington (A '19), Manager, Agency and Specialties Division, Westinghouse Electric Corporation, St. Louis, Mo., died April 9, 1949. A native of Crawford County, Kans., he was born March 19, 1894. Following his graduation from Tri-State College with an electrical engineering degree in 1914, he joined the Kansas Gas and Electric Company, Pittsburg, Kans. One year later, he became associated with Westinghouse in their East Pittsburgh, Pa., branch. Subsequent to taking the company's graduate apprentice course, he was placed in the Transformer Section of the Supply Department. In 1917, he was made a salesman in the firm's St. Louis office. One year later, he joined the United States Army, where he was a mechanic and cadet in the Aviation Section. After his discharge in 1919, he was reinstated to his selling position with Westinghouse. In later years with the organization, he was successively St. Louis Manager and Executive Assistant to the District Manager. He had been Manager of the Agency and Specialties division for the last eight years. Mr. Washington was a former president of the St. Louis Electrical Board of Trade. He was Chairman of the St. Louis Section of the AIEE, 1933–34.

William Ewart Ross (M '38), Assistant to the President, Canadian General Electric Company, Toronto, Ontario, died May 5, 1949. Identified with the company for three decades, he was a native of Ardaley, Yorkshire, England, born March 2, 1889. Educated at the University of Sheffield in England, he worked as an electrician in that country prior to coming to Canada in 1912. He served with the Canadian armed forces during World War I. In 1919, he joined the Canadian General Electric Company, Peterboro, Ontario, as a draftsman. During the next decade his designations were assistant engineer and engineer successively in the Industrial Control Department. In 1929, he was made engineer in charge of industrial control and two years later, he was transferred to the company's Toronto office, where he helped to organize and manage the Engineering Service Department. Mr. Ross was appointed manager of the Apparatus Sales Department in 1938. Ten years later, he was named Assistant to the President. A former member of the Canadian Standards Association, he belonged to the Engineering Institute of Canada and was a past president of the Engineers Club of Toronto.

Cyrus Austin Leland (M '27), President, Iowa Power and Light Company, Des Moines, died May 25, 1949. Born June 16, 1887, in El Dorado, Kans., he was a graduate in electrical engineering of Kansas University, class of 1910. Beginning his career with the Allis-Chalmers Manufacturing Company, he subsequently worked for the Portland Cement Company, Independence, Kans., the Kansas City (Mo.) Terminal Railway Company, and the Illinois Traction Company, Atchison, Kans. He left his position of general superintendent and manager with the last company in 1917 to join the Armed Forces. Following two years of military service, he was factory manager for the Bailor Plow Company, Atchison, and in 1920, he became manager of the Illinois Traction Company. Joining the Kansas Power and Light Company, Topeka, in 1923, as a construction engineer, he subsequently became vice-president and general manager. Mr. Leland went to Des Moines in 1927 to assume the duties of vice-president and general manager with the Des Moines Electric Light Company and the Iowa Power and Light Company. He was named president of Iowa Power and Light in 1933. From 1931 to 1933, he was president of Kansas Power and Light, in addition to his Des Moines responsibilities.

Samuel Mills Dean (A '25, M '41, F '46), Chief Engineer of the System, Detroit (Mich.) Edison Company, died May 31, 1949. He had been with the company nearly one-quarter of a century. A native of Traverse City, Mich., born July 15, 1891, he attended Michigan State College, receiving his electrical engineering degree in 1914. His first position thereafter was with the Michigan Miller's Mutual Fire Insurance Company, Lansing. In 1916, he joined the General Electric Company, Schenectady, N. Y. After taking the test course, he became night head of a motor-generator test section, and later, he worked in the general office commercial department. Mr. Dean went to the company's Chicago district office in 1919 to assume the position of sales engineer. Two years later, he was transferred to Detroit, where he was assistant manager in the Sales Department. Becoming associated with the Detroit Edison Company in 1925, he was appointed senior engineer in charge of the Engineering Division two years later. In 1930, he was made chief assistant superintendent of the electrical system. Thirteen years afterwards, he became chief engineer of the system. The author of several articles

on power system design and operation, he was a member of Tau Beta Pi and the Engineering Society of Detroit. He served on the following AIEE committees: Power Transmission and Distribution, 1933–34; Edison Medal, 1946–49 (was Chairman); Planning and Co-ordination, 1948–49.

Joseph John Doonan (M '33), retired General Plant Employment Supervisor, Southern Bell Telephone and Telegraph Company, Atlanta, Ga., died May 21, 1949. A native of Atlanta, he was born April 30, 1882. In the early part of his career with Southern Bell he was successively acting division engineer located in Atlanta, and division engineer in Charlotte, N. C., and in New Orleans, La. In 1926, he was named Florida superintendent of construction at Jacksonville. Two years later, his designation was Florida plant superintendent. In 1932, he returned to Atlanta, becoming Georgia plant superintendent. Subsequently he was appointed general plant engineer, and in 1945, he assumed the duties of general plant employment supervisor.

MEMBERSHIP • • • •

Recommended for Transfer

The Board of Examiners at its meeting of June 16, 1949, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the secretary of the Institute. A statement of valid reasons for such objections must be furnished and will be treated as confidential.

To Grade of Fellow

Beeman, D. L., mgr. ind. powr div., General Elec. Co., Schenectady, N. Y.
Caldwell, B. H., Jr., section engr., General Elec. Co., Schenectady, N. Y.
Cooney, W. H., asst. to mgr. of engg., transformer & allied products div., General Elec. Co., Schenectady, N. Y.
Holman, H. R., chief engr., National Carbon Co., Inc., Cleveland, Ohio
Kennedy, L. F., application engr., central sta. engg. div., General Elec. Co., Schenectady, N. Y.
Kierstead, F. H., sec. engr., power trans. engg. div., General Elec. Co., Pittsfield, Mass.
Koontz, J. A., jr., chief. div. of hydroelectric & trans. engrg., Pacific Gas & Elec. Co., San Francisco, Calif.
Livingston, O. W., consulting engr., electronics & regulator control engg. div., General Electric Co., Schenectady, N. Y.
Newell, H. H., prof. of elec. engg., Worcester Polytechnic Inst., Worcester, Mass.
Peirce, W. T., chief cable engr., American Steel & Wire Co., Worcester, Mass.
Schamberger, S. O., chief engr., New York Power & Lt. Corp., Albany, N. Y.
Scoville, M. E., section engr., capacitor sec., General Elec. Co., Pittsfield, Mass.
Sellers, J. F., engineer-in-charge, D-C sec., Allis-Chalmers Mfgr. Co., Milwaukee, Wis.
Taylor, H. D., div. engr., General Elec. Co., Schenectady, N. Y.
Westendorf, W. F., research engr., research lab., General Elec. Co., Schenectady, N. Y.
Winje, S. W., mgr. elec. operations, Ft. Wayne Div., Indiana & Michigan Elec. Co., Ft. Wayne, Ind.
16 to grade of Fellow

To Grade of Member

Barnes, E. W., elec. engr., Indianapolis Power & Lt. Co., Indianapolis, Ind.
Barnwell, J. R., elec. engr., Tennessee Valley Authority, Chattanooga, Tenn.
Beckman, V. C., aeronautical research scientist, National Advisory Comm. for Aeronautics, Cleveland Airport, Ohio
Bedell, L., relay & comm. engr., Southwestern Public Service Co., Amarillo, Tex.
Best, L. M., transportation engr., General Elec. Co., Los Angeles, Calif.
Bingham, H. C., supervisor, Cleveland Elec. Illuminating Co., Cleveland, Ohio
Bittrick, W. E., engr., Consolidated Gas Elec. Lt. & Pr. Co., Baltimore, Md.
Call, R. D., C&A engr., Westinghouse Elec. Corp., St. Louis, Mo.
Cameron, C. F., elec. engg. professor, Oklahoma A & M College, Stillwater, Okla.
Chinlund, D. K., engr., Illinois Bell Tel. Co., Chicago, Ill.
Clems, J. M., sales & app. engr., Kirkhof Elec. Co., Grand Rapids, Mich.
Coffman, A. L., design draftsman, Monsanto Chemical Co., St. Louis, Mo.
Degge, K. R., elec. engr., Companhia Auxiliar de Empresas Electricas Brasileiras, Rio de Janeiro, Brazil
Fisher, A., section engr., General Elec. Co., Lynn, Mass.
Forsman, M. E., asst. prof. of elec. engg., Tulane Univ., New Orleans, La.
Gitzendanner, L. G., engr., General Elec. Co., Schenectady, N. Y.
Hansen, T. A., elec. engr., Puget Sound Power & Lt. Co., Seattle, Wash.
Hantla, O. R., elec. engr., Kansas Gas & Elec. Co., Wichita, Kans.
Hedley, J. B., elec. engr., B.C. Power Comm., Victoria, British Columbia, Canada
Herwald, S. W., mgr., development sec., Westinghouse Elec. Corp., Pittsburgh, Pa.
Hoffman, G. L., technical engr., Consolidated Gas Elec. Light & Pr. Co., Baltimore, Md.
Hoffman, S. O., elec. engr., San Francisco Naval Shipyard, San Francisco, Calif.
Lake, C. J., application engr., central sta. engg. div., General Elec. Co., Schenectady, N. Y.
Lenaner, H. W., design engr., Westinghouse Elec. Corp., Newark, N. J.
MacFee, F. O., jr., engr., General Elec. Co., Schenectady, N. Y.
McConnell, A. J., application engr., General Elec. Co., Schenectady, N. Y.
Moore, H. G., section engr., loco & car equip. divs., General Elec. Co., Erie, Pa.
Norton, V. E., elec. engr., Control Corp., Minneapolis, Minn.
Rutter, J. R., engr., Illinois Bell Tel. Co., Chicago, Ill.
Samuel, R. W., engr., General Elec. Co., Schenectady, N. Y.
Sanders, R. B., engr. P-4, garrison dist., Corps. of Engineers, Ft. Lincoln, Bismarck, N. Dak.
Slater, H. A., elec. engr., Tennessee Valley Authority, Chattanooga, Tenn.
Snyder, W. W., sr. engr., Sylvania Elec. Products, Flushing, N. Y.
Spandau, E. F., radio engr., headquarters, Air Materiel Command, Wright-Patterson Air Force Base, Dayton, Ohio
Sprague, M. B., equipment costs engr., The Southern New England Tel. Co., New Haven, Conn.
Stark, O. P., jr., vice-pres. & const. mgr., Hoosier Engg. Co., Columbus, Ohio
Stephens, E. H., Wichita mgr., Westinghouse Elec. Corp., Wichita, Kans.
Stetler, H. L., associate elec. engr., Tennessee Valley Authority, Chattanooga, Tenn.
Terpak, S., asst. div. engr., General Elec. Co., Pittsfield, Mass.
Todd, R. C., asst. supervisor, Battelle Memorial Inst., Columbus, Ohio
Varenhorst, F. G., dial equip. engr., Illinois Bell Tel. Co., Chicago, Ill.
Walker, G. S., assoc. prof. of elec. engg., Univ. of Alabama, Univ., Ala.
Walton, O. H., engr., Illinois Bell Tel. Co., Chicago, Ill.
Warnock, W. J., engr., General Elec. Co., Schenectady, N. Y.
Yoder, R. D., Columbus branch mgr., Cutler-Hammer, Inc., Columbus, Ohio
45 to Grade of Member

Applications for Election

Applications for admission or re-election to Institute membership have been received during the month ending July 5, 1949, from the persons listed below. Any objection to the election of any of these candidates should so inform the Secretary before August 25, 1949, or October 25, 1949, if the applicant resides outside of the United States, Canada, or Mexico. All but a small number of the applications for Associate membership listed below have been received from Student members whose term of such affiliation will not expire until April 30, 1950; action upon such applications therefore will be deferred until that time in practically all cases.

To Grade of Fellow

Engstrom, E. W., R.C.A., Princeton, N. J.
1 to grade of Fellow

To Grade of Member

Arberry, J. P. E., Pittsburgh Plate Glass Co., Pittsburgh, Pa.
Bell, J. W., Bell Tel. Labs., New York, N. Y.
Bhattacharya, M., Govt. of West Bengal, India, c/o Embassy of India, Washington, D. C.
Booker, C. A., N. E. Power Service Co., Boston, Mass.
Carpenter, L. J., General Elec. Co., Schenectady, N. Y.
Conte, U. E., Mutual Boiler Insurance Co., Boston, Mass.
Cooper, M. T., White Elec. Const. Co., Columbus, Ga.
Cranston, W. E., jr., Thermador Elec. Mfg. Co., Los Angeles, Calif.
Deshpande, M. V., University Station, call box No. 27, Urbana, Ill.
Devine, J. J., The Kellex Corp., New York, N. Y.
Domenach, L., Cables de Lyon, Lyon (Rhone), France
Grepe, F. Y., Canadian Controllers Ltd., Toronto, Ontario, Canada
Hoffmann, J. A. J. L., Brussels Univ., Brussels, Belgium
Holloway, S. D., Iraq Petroleum Co., Ltd., Tripoli, Lebanon, Middle East
Jamart, G. E. J., De Leuw, Cather & Co., San Francisco, Calif.
Johnson, T. A., Sociedad Argentina de Ingenieros Proyectistas, Mendoza, Argentina, South America
Kennedy, N. D., Simplex Wire & Cable Co., Cambridge, Mass.
Kerawalla, R. D., Standard Telephone & Cables Ltd., London, England
Khalid, M. H., Electricity Dept., Nowshera, N.W.F.P., Pakistan
Lamming, J. H., S. & C. Elec. Co., Chicago, Ill.
Lehmann, W. H. G., General Elec. Supply Corp., Bridgeport, Conn.
Lindquist, L. A., Stone & Webster Engg. Corp., Boston, Mass.
Mehndiratta, R. L., Govt. Steam Power Station, Chandausi, U. P. India
Montgomery, R. A., General Elec. Co., Schenectady, N. Y.
Mulvey, B. J., General Elec. Co., Bridgeport, Conn.
O'Donnell, J. J., Johns-Manville Sales Corp., New York, N. Y.
Parr, B. F., Westinghouse Elec. Corp., Mansfield, Ohio
Porter, G. A., The Detroit Edison Co., Detroit, Mich.
Richards, A. H., Cleveland Elec. Illuminating Co., Cleveland, Ohio
Salley, E. C., Public Service Comm., Columbia, S. C.
Salo, J. V., Public Service Co., of New Hampshire, Manchester, N. H.
Solvey, L. A., Rural Electrification Admin., Washington, D. C.
Stafford, J. W. (re-election), Automatic Elec. Co., Chicago, Ill.
Subramanian, G., Indian Posts & Telegraphs Dept., Alipore, Calcutta, India
Thomas, G. L., Elec. Motor Repair Co., Inc., Waterbury, Conn.
Voiz, C., Pennsylvania State College, State College, Pa.
Wascavage, J. A., Goodyear Aircraft Corp., Akron, Ohio
Wright, F. S., Tennessee Eastman Corp., Kingsport, Tenn.
38 to grade of Member

To Grade of Associate

United States, Canada, and Mexico

1. NORTH EASTERN

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Woerner, F. R., Texas Elec. Service Co., Wichita Falls, Tex.
Wood, O. W., Jr., 1315 N. 5th, Wichita Falls, Tex.
Woodcock, C. A. (Student), Univ. of Kansas, Lawrence, Kans.
Wright, D. B. (Student), Univ. of Missouri, Columbia, Mo.
Wright, S. F., 120 Drive C., Sunflower, Kans.
Wyhs, A., 1821 Watson, St. Charles, Mo.
Young, C. C., Jr. (Student), Univ. of Texas, Austin, Tex.
Zemanek, J., Jr. (Student), Univ. of Texas, Blessing, Tex.
Zimmerer, C. B., 2753-A Magnolia Ave., St. Louis, Mo.

8. Pacific

Adler, R. K., 299 Glendora Ave., Long Beach, Calif.
Ambrosini, A. T., 1803 Austin Way, Santa Rosa, Calif.
Ames, C. B., 5843 Chabot Rd., Oakland, Calif.
Astad, F. (Student), University of Southern Calif., Los Angeles, Calif.
Baldelli, H., 335 Ohio, Richmond, Calif.
Barnes, R., 1317 Maine St., Richmond, Calif.
Barr, H. J., Gilfillan Bros., Inc., Los Angeles, Calif.
Beal, O. W., Jr., 3053 Shattuck Ave., Berkeley, Calif.
Bennett, R. R., Calif. Inst. of Tech., Pasadena, Calif.
Benz, R. P., Arizona Edison Co., Inc., Phoenix, Ariz.
Blomquist, W. H., Naval Civil Engineer, Vallejo, Calif.
Brooks, J. L., 2315 Dwight Way, Berkeley, Calif.
Brubaker, E. A., 1456 Washington Ave., Albany, Calif.
Bryson, R. G., 1835 Addison St., Berkeley, Calif.
Bulkley, E. O., 1532 Indiana Ave., So. Pasadena, Calif.
Casey, A. F., 216 S. College St., LaHabra, Calif.
Chalmers, S. M., 723 E. Moreland, Phoenix, Ariz.
Chambers, E. H., Pacific Gas & Elec. Co., Oakland, Calif.
Chester, J. E., Station *KWRN*, Reno, Nev.
Cokas, G., 1331 W. 89th St., Los Angeles, Calif.
Collins, R. G., 1080-C W. 31st St., Los Angeles, Calif.
Comstock, G. E., III, 293 S. Chester Ave., Pasadena, Calif.
Coogan, J. H., 124—14th St., Oakland, Calif.
Cook, V. C., Jr., Westinghouse Elec. Corp., Los Angeles, Calif.
Cox, J. W., Jr., 3434 McClintock Ave., Los Angeles, Calif.
Dominguez, C. A. (Student), Univ. of S. Calif., Los Angeles, Calif.
Drapes, A., Ricketts House Caltech, Pasadena, Calif.
Elfrig, G. R., Bldg. 212 B., Stanford Village, Stanford, Calif.
Ekparian, J., 4357 Eagle Rock Blvd., Los Angeles, Calif.
Eisenstein, N. H., Calif. Inst. of Tech., Pasadena, Calif.
Engh, P. B., 11540 Pope Ave., Lynwood, Calif.
Eriqat, A., 2506 College Ave., Berkeley, Calif.
Escalante, L. E., 222 Commercial St., Richmond, Calif.
Fast, D. K., Pacific Gas & Elec. Co., San Francisco, Calif.
Fenton, N. L., 1818 N. 12th St., Phoenix, Ariz.
Freiberg, L., Friden Calc. Machine Co., San Seandro, Calif.
Galindo, L. A., 5111 Varne St., VanNuys, Calif.
Gardner, C. R., Jr., 1732 W. 23rd St., Los Angeles, Calif.
Goothers, J. W., 686 Post St., San Francisco, Calif.
Gift, M. F., 4505½ Prospect Ave., Los Angeles, Calif.
Harris, R. L., Jr., 2304 Dwight Way, Berkeley, Calif.
Haynes, J. I., 3645 Grand, Walnut Park, Calif.

Heard, H. G., 2732 Hillegass Ave., Berkeley, Calif.
Hendricks, G. R., Douglas Aircraft Co., Inc., Santa Monica, Calif.
Herle, S. J., 829 Washington Blvd., Montebello, Calif.
Hoexter, H., 2417 Blake St., Berkeley, Calif.
Hoffman, S., 1735 LeRoy, Berkeley, Calif.
Houghtaling, E. J. (Student), Univ. of Nevada, Reno, Nev.
Jenkins, G. W., Anachrome Corp., South Gate, Calif.
Jenks, R. P., F. J. Early, Jr., Co., San Francisco, Calif.
Johnson, D. A., Dept. of Water & Power, Los Angeles, Calif.
Jones, L. V., Univ. of Calif., Bowles Hall, Berkeley, Calif.
Kasai, G. S., 2211 Pine St., San Francisco, Calif.
Katz, I., Box T, Pacoima, Calif.
Kidder, P. H., 932 Lehigh St., Altadena, Calif.
Kim, F., 3833 Telegraph Ave., Oakland, Calif.
Kirsch, M. A., Pacific Gas & Elec. Co., San Francisco, Calif.
Kopulsky, S., 2019 West View St., Los Angeles, Calif.
Kostelac, J. F., 645 S. Mentor, Pasadena, Calif.
Kreider, P. A., Marquardt Aircraft Co., Oxnard, Calif.
Krumbols, I. L., 395 N. Euclid Ave., Pasadena, Calif.
Kuefler, P. M., Jr., 8419 Halldale Ave., Los Angeles, Calif.
Lackey, F. J., J. W. Hill, Los Angeles, Calif.
Larsen, A., 1671 Loma Vista St., Pasadena, Calif.
Larson, H. T., Natl. Bureau of Standards, W. Los Angeles, Calif.
Leseberg, R. H., 1451 Echo Park Ave., Los Angeles, Calif.
Likins, R. W., 2957 Southwood Dr., Alameda, Calif.
Longley, F. P. C., The Pacific Tel. & Tel. Co., San Francisco, Calif.
Macmillan, R. S., California Inst. of Tech., Pasadena, Calif.
Magid, M., 2724 Channing Way, Berkeley, Calif.
Marosz, M. J., 3993¼ So. Menlo Ave., Los Angeles, Calif.
Mazer, L., 1955 Chestnut St., Berkeley, Calif.
McLeod, D. L., Univ. of Nevada, Reno, Nev.
Meyer, J. G., 2852 California St., San Francisco, Calif.
McIntosh, E. R., Southern California Edison Co., Los Angeles, Calif.
McNichols, J. T., Southern California Edison Co., Los Angeles, Calif.
McPherson, W. R., Jr., Major, USAF, Davis-Monthan AFB, Tucson, Ariz.
Miller, E. F., 8664 Garden View Ave., South Gate, Calif.
Millstone, S. D., 1522 N. VanNess Ave., Los Angeles, Calif.
Nakamura, M., 5750 Harbord Dr., Oakland, Calif.
Narasimhan, R., 332 S. Catalina Ave., Pasadena, Calif.
Paulson, H. R., 1221 W. 19th St., Long Beach, Calif.
Peterson, F. W., 1339 N. Park Ave., Tucson, Ariz.
Phelan, J. E., c/o R. E. Carruthers, Seal Beach, Calif.
Potter, J. O., Box 312, Novato, Calif.
Richardson, J. F., Jr., 217 W. Cypress Ave., Redlands, Calif.
Ruesner, W. I., Hughes Aircraft Co., Culver City, Calif.
Schneider, C. A., Jr., 906 Monroe St., Santa Clara, Calif.
Scott, W. G., Salt River Valley Water Users Assn., Phoenix, Ariz.
Shaffier, N., State of California, Los Angeles, Calif.
Simpson, R. J., Univ. of S. Calif., Los Angeles, Calif.
Skolnick, J., 601—63rd St., Oakland, Calif.
Smid, J., 6933 Marconi St., Huntington Park, Calif.
Smith, D. L., 1061½ Spaulding Ave., Burbank, Calif.
Smith, H. S., Bechtel Corp., San Francisco, Calif.
Smith, R. L., 4222—34th St., San Diego, Calif.
Sneed, R. C., Jr., 341 Pacific Ave., Piedmont, Calif.
Soule, C. C., Dept. of Water & Power, Los Angeles, Calif.
Spehar, W. P., 2613 Durant Ave., Berkeley, Calif.
Sterling, W. Calif. State Polytech College, San Luis Obispo, Calif.
Stevens, L. D., Jr., Univ. of California, Berkeley, Calif.
Swartz, R. L., 416 Yale Ave., Berkeley, Calif.
Teague, R. J., Jr., 705 Elvira Ave., Redondo Beach, Calif.
Temple, F. J., 1139 S. Abbot, San Gabriel, Calif.
Theis, F. J., U. S. Army, Oakland Army Base, Oakland, Calif.
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Wenick, F., Lear, Culver City, Calif.
Westburgh, V. B., 1661 Castilleja, Palo Alto, Calif.
Wienand, F. B., The Pacific Tel. & Tel. Co., San Francisco, Calif.
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Woodbury, S., Bureau of Reclamation, Phoenix, Ariz.
Woodruff, J. B., Dept. of Water & Power, Los Angeles, Calif.
Wyche, F. R., 310 "B" S. Chapel, Alhambra, Calif.
Yarbrough, H. C., Box 4674, Tucson, Ariz.

9. North West

Aburano, F., Boeing Airplane Co., Seattle, Wash.
Adams, J. Q., Boeing Airplane Co., Seattle, Wash.
Allen, S. L., Jr., 1559 Lincoln Ave., Salt Lake City, Utah
Anderson, D. A., Intermountain Theatres Supply Co., Salt Lake City, Utah
Barger, R. D., R. R. #1, Custer, Wash.
Beck, V. L., 3059 S. W. Cascade Dr., Portland, Oreg.
Benjamin, G. R., Winchester, Idaho
Bernstein, T., Boeing Airplane Co., Seattle, Wash.
Bigelow, G. W., 317 N. 12, Corvallis, Oreg.
Blake, C. W., Bonneville Power Admin., Portland, Oreg.
Bosshart, W. R., Bonneville Power Admin., Portland, Oreg.
Brown, J. E., 935—25th Ave., Seattle, Wash.
Burlingham, A. C., P. O. Box 144, Rockaway, Oreg.
Carter, J. (Student), Univ. of Washington, Seattle, Wash.
Caswell, J. A., Route 3, Box 3460 K, Edmonds, Wash.
Chappell, J. E., Box 128, Opportunity, Wash.
Chittinanda, C. (Student), Univ. of Washington, Seattle, Wash.
Christensen, R. L., 1568 E. Kappa Ave., Salt Lake City, Utah
Clegg, J. C., 1532 Michigan Ave., Salt Lake City, Utah
Coberly, W. C., 4950 N. "A" St., Spokane, Wash.
Dam, N. J., 1113 Lee Blvd., Richland, Wash.
Decco, L. W., 619 S. Jackson, Butte, Mont.
Derksema, M. C., Dave M. Lee Co., Seattle, Wash.
Downing, J. R., 4059—6th Ave. N. E., Seattle, Wash.
Dunn, H. A., Jr., Route 4, Box 187, Corvallis, Oreg.
Erdle, H. R., 503 Gladstone St., Pullman, Wash.
Ferguson, R. E., 312 S. 12th St., Corvallis, Oreg.
Fisher, R. T., P. O. Box 238, Moscow, Idaho
Foss, G. V., 3716 N. E. Hassalo St., Portland, Oreg.
Gens, R. S., 3394 S. E. 21st Ave., Portland, Oreg.
Gibbs, F. R., General Elec. Co., Bridger, Mont.
Gill, F. K., Rt. 2, Box 2-C, Washougal, Wash.
Glanton, R. J., 20 W. Koch St., Bozeman, Mont.
Groo, R. M., 675 W. 4th North, Salt Lake City, Utah
Gross, F. H., Bonneville Power Admin., Portland, Oreg.
Hagiwara, F. K., 341—8th Ave., Seattle, Wash.
Hamilton, C. L., Boeing Aircraft Co., Seattle, Wash.
Hammond, C. K., 1412 W. Nora, Spokane, Wash.
Hansen, D. T., Bureau of Reclamation, Ephrata, Wash.
Hansen, J. T., 119 N. Ninth St., Miles City, Mont.
Hazelton, L., 1029 East 62nd St., Tacoma, Wash.
Higgins, F. G., 1730 W. Dean, Spokane, Wash.
Hill, H. L., 965 Pine St., Salem, Oreg.
Hill, J. R., 125 So. 9th E., Salt Lake City, Utah
Holmlund, C., 1561 E. Sigma #6, Salt Lake City, Utah
Hopkins, D. L., 308—8th St., Great Falls, Mont.
Houck, D. A., 4816 Mayflower St., Seattle, Wash.
Howard, J. S., 6-C-St., Bozeman, Mont.
Huff, J. N., Boeing Airplane Co., Seattle, Wash.
Hunter, K. H., Seattle City Light, Seattle, Wash.
Johns, D. C., 6-B-St., Bozeman, Mont.
Kelly, W. L., 911 S. 10th, Bozeman, Mont.
Kelley, R. L., Bonneville Power Admin., Vancouver, Wash.
Lafromboise, N. D., 1507 Porter St., Enumclaw, Wash.
Lazarus, A., Boeing Airplane Co., Seattle, Wash.
Lee, R., 1955 S. E. 28th Ave., Portland, Oreg.
Leva, J. H., The Pacific Tel. & Tel. Co., Portland, Oreg.
Mackenstadt, R. A., E. 3811—6th Ave., Spokane, Wash.
Marihart, D. J., R. R. #1, Carnation, Wash.
McKinney, R. L., Bonneville Power Admin., Portland, Oreg.
Mills, R. D., Box 262 College Station, Pullman, Wash.
Moody, T. W., 712 S. Willson, Bozeman, Mont.
Moore, E. C., 1444 S. 12th St., Salem, Oreg.
Moore, J., Bonneville Power Admin., Portland, Oreg.
Myers, M. R. (Student), Montana State College, Bozeman, Mont.
Nichols, R. S., 308 Kings Road, Corvallis, Oreg.
Nordlund, L. H., 4322 So. Bell, Tacoma, Wash.
Odekirk, M. D., 1579 E. Sigma Ave., Salt Lake City, Utah
Okeson, R. H. (Student), Univ. of Washington, Seattle, Wash.
O'Neal, J. N., 7104 S. E. 19th Ave., Portland, Oreg.
Palmquist, N. B., Jr., 502 S. E. 69th Ave., Portland, Oreg.
Perry, F. S., Boeing Airplane Co., Seattle, Wash.
Perry, R. R., P. O. Box 435, Glendive, Mont.
Peterson, K. N., Boeing Airplane Co., Seattle, Wash.
Poehls, V. L., 3707—4th Ave. S., Billings, Mont.
Pooley, R. R., 720 North 13th St., Corvallis, Oreg.
Rakel, W. F., West Linn, Oreg.
Richardson, C. B., 2-A-St., Bozeman, Mont.
Roy, G. M., General Elec. Co., Richland, Wash.
Rubel, R. E., c/o F. E. Beckwith, 222 Cedar St., Shelton, Wash.
Saiget, R. K., 374 ½ Astor St., Astoria, Oreg.
Samson, C. A., 4248 Pasadena Place, Seattle, Wash.
Schwager, H. H., Schwager-Wood Corp., Portland, Oreg.
Silverman, S. W., Boeing Aircraft Co., Seattle, Wash.
Skoor, P. O., 218 E. 17th, Olympia, Wash.
Smith, G. H., 4524 N. E. Fremont, Portland, Oreg.
Sullivan, G. L., 1321 East Union St., Seattle, Wash.
Swan, A. W., I. B. M. Corp., Seattle, Wash.
Tallman, R. J., 3741—15th N. E., Seattle, Wash.
Tamada, H. S., Boeing Airplane Co., Seattle, Wash.
Taylor, D. C., Box 523, McMinnville, Oreg.
Taylor, L., 1205 Maple, Pullman, Wash.
Temte, J., 240 Bridgeway, Everett, Wash.
Thompson, A. G., Pacific Tel. & Tel. Co., Seattle, Wash.
Vogele, F. C., Northern Pacific Railway, Livingston, Mont.
White, N. O., 2111 S. E. Orange Ave., Portland, Oreg.
White, W. D., 10 Cedar Ave., Bozeman, Mont.
Wilson, L. A. (Student), Univ. of Washington, Seattle, Wash.
Wilson, R. A., (Student), Univ. of Washington, Seattle, Wash.
Wong, D. D., 233 N. E. Tenth Ave., Portland, Oreg.
Woods, R. E., 41 E. 1st North, Salt Lake City, Utah

10. Canada

Anderson, L. W., RCA Victor, Montreal, Quebec, Canada
Bingley, C. R. T., 3006—5A St., W., Calgary, Alberta, Canada
Bishop, A. A., City of Calgary Elec. Lt. Dept., Calgary, Alberta, Canada
Brooks, A. A., Hydro Elec. Power Comm. of Ontario, Toronto, Ontario, Canada
Bryant, D. W., Toronto Hydro Elec. System, Toronto, Ontario, Canada
Cass, S., Ontario Hydro Elec. Power Comm., Toronto, Ontario, Canada
Christie, R. G., Canadian Ohio Brass Co. Ltd., Niagara Falls, Ontario, Canada
Clarke, J. P., Canadian Westinghouse Co. Ltd., Hamilton, Ontario, Canada
Corio, P., Canadian Broadcasting Corp., Montreal, Quebec, Canada
Correll, W. H., Hydro Elec. Power Comm. of Ont., Toronto, Ontario, Canada
Davison, J. M., Lt. RCN, HMCS "Stadaconna," Halifax, Nova Scotia, Canada
Dorward, F. R., Canadian General Elec. Corp., Peterboro, Ontario, Canada
Elliot, G. W., Canadian Westinghouse Co., Ltd., Hamilton, Ontario, Canada
Forest, D. J., Alberta Government Telephones, Edmonton, Alberta, Canada
Galipeau, C., Canadian General Elec. Co., Peterborough, Ontario, Canada
Gardner, D. W., Ferranti Elec. Ltd., Mt. Dennis, Toronto, Ontario, Canada
Ghosh, S. K., 3506 University St., Montreal, Quebec, Canada
Gunnham, J. A., Canadian National Rwys., Montreal, Quebec, Canada
Holmes, D. L., Howard Smith Paper Mills Ltd., Montreal, Quebec, Canada
Holmes, W. H., Station *RCAF*, Edmonton, Alberta, Canada
Huxtable, V. J., Hydro Elec. Power Comm. of Ont., Toronto, Ontario, Canada
Judd, A. S., Hydro Elec. Power Comm. of Ont., Toronto, Ontario, Canada
King, E. H., Bell Tel. Co. of Canada, Toronto, Ontario, Canada
Kuster, R. E., Bell Tel. Co. of Canada, London, Ontario, Canada
Kovacs, R. V., Walter Dow Consulting Engrs., Montreal, Quebec, Canada
La Douceur, L. J., 1232 Gladstone, Windsor, Ontario, Canada
Lauzon, E. P., Canada Packers, Ltd., Montreal, Quebec, Canada
Madsen, E., Canadian Westinghouse Co., Ltd., Hamilton, Ontario, Canada
Mather, H. E., Dept. of Public Works, Calgary, Alberta, Canada
McMullan, J. R., 28 Blandford Ave., Toronto, Ontario, Canada
McPherson, N. F., West Monkton, Ontario, Canada
McIville, J., Canadian Forest Products, New Westminster, British Columbia, Canada
Nevison, R. D., Hydro-Elec. Power Comm., Toronto, Ontario, Canada
Nixon, S., Canadian General Elec. Corp., Peterborough, Ontario, Canada
Ormrod, K. R., Canadian General Elec. Co., Peterborough, Ontario, Canada
Overy, E. M., Calgary Power, Ltd., Calgary, Alberta, Canada
Pattison, L. A., Shawinigan Water & Power Co., Montreal, Quebec, Canada
Perreault, J., Hydro-Quebec, Montreal, Quebec, Canada
Pigeon, P., Quebec Hydroelec. Comm., Montreal, Quebec, Canada
Rogers, H. F., 2106—18A St., S. W., Calgary, Alberta, Canada
Roper, G. J., 1717—5th Ave. N., Lethbridge, Alberta, Canada
Rosser, R. D. A., Canadian Westinghouse Co., Ltd., Edmonton, Alberta, Canada
Rutberg, J. R., City Light & Power Dept., Edmonton, Alberta, Canada
Sawyer, W. A., Canadian General Elec. Co., Toronto, Ontario, Canada
Somers, R. T., 3438 St. Famille St., Montreal, Quebec, Canada
Speakman, F. G., Bell Tel. Co., Montreal, Quebec, Canada
Vallee, L. H., British Columbia Power Comm., Vancouver, British Columbia, Canada
Whincup, H. A., Hydro Elec. Power Comm. of Ontario, Toronto, Ontario, Canada
Wight, W., Westinghouse Elec. Corp., Hamilton, Ontario, Canada

Elsewhere

Alhashmi, H. A., College of Engg. & Tech., Aligarh, India
Askar Gardezi., B. H., P.W.D. Bannu N.W.F.P., Pakistan
Cope, J. H. W., Brimadown Power Station, Enfield, Middlesex, England
Furstenau, B. W., Lago Transport & Oil Co., Aruba, Netherlands West Indies
Gomez, A. (re-election), Compania Nacional de Fuerza Electrica, Antofagasta, Chile, South America
Goossens, P. J., S. A. J. VanDenHeuvel Portland Cement Co., Hemiksem, Belgium
Hayes, W. F., Creole Petroleum Corp., Caracas, Venezuela, South America
Lowrie, D. W., Bolivian Power Co., Ltd., La Paz, Bolivia, South America
Messano, G. F., Ministerio daMarinha, Rio de Janeiro, Brazil, South America
Miraz, K. K., Baghdad Light & Power Co., Baghdad, Iraq
Parris, E. E., Guyuni Gold Fields, Guyuni River, British Guiana, South America
Rose, F. G., Bulolo Gold Dredging Ltd., Bulolo, New Guinea
Tanguis, W. P., International Machinery Co., Lima, Peru, South America

Total to grade of Associate

United States, Canada, and Mexico, 2,221
Elsewhere, 13

Report of the Board of Directors

THE BOARD OF DIRECTORS of the American Institute of Electrical Engineers presents to the membership its 65th annual report, covering the fiscal year ending April 30, 1949. It contains a brief summary of the principal activities of the Institute during the year, a general balance sheet showing the financial condition of the Institute at the close of the fiscal year, a statement of cash receipts and disbursements, and a schedule of securities owned. Additional information regarding the activities appeared in issues of *Electrical Engineering*.

BOARD OF DIRECTORS' MEETINGS

Five meetings of the Board of Directors were held during the year, two in New York, N. Y., one in Mexico, Federal District, Mexico, one in Milwaukee, Wis., and one in Dallas, Tex.

Information regarding many of the more important matters which were considered by the Board of Directors appeared in various issues of *Electrical Engineering*.

INSTITUTE VISITS BY PRESIDENT LEE

Alabama

Southern District Meeting, Birmingham

Arizona

Arizona Section and University of Arizona Branch, Phoenix

California

Stanford University Branch, Stanford; University of California Branch, Berkeley; University of Santa Clara Branch officers, Santa Clara; San Francisco Section; California Institute of Technology Branch, Pasadena; University of Southern California Branch, Los Angeles; Los Angeles Section; San Diego Section

Canada

Vancouver Section and University of British Columbia Branch officers; Toronto Section; Montreal Section; St. Maurice Valley Subsection, Shawinigan Falls; Ottawa Subsection; Niagara International Section, Niagara Falls, N. Y.

Colorado

Denver Section and University of Wyoming, Colorado Agricultural and Mechanical College, University of Denver, and University of Colorado Branches; University of Colorado Branch, Boulder

District of Columbia

Middle Eastern District Meeting, Washington; Joint AIEE-Institute of Radio Engineers-National Bureau of Standards Conference on High-Frequency Measurements, Washington

Florida

South Florida Subsection, Miami; North Florida Subsection, Gainesville; University of Florida AIEE-IRE Joint Student Branch, Gainesville

Illinois

Chicago Section, with Counselors and Chairmen of Branches at Illinois Institute of Technology and Northwestern University; dedication of new Electrical Engineering Building, University of Illinois, Urbana

Indiana

Fort Wayne Section; University of Notre Dame Branch, Notre Dame; South Bend Section

Maryland

Maryland Section and Johns Hopkins University Branch, Baltimore

Massachusetts

Pittsfield Section; Summer General Meeting, Swampscott

Michigan

Michigan Section, Detroit; joint meeting of University of Detroit and Wayne University Branches, Detroit; Michigan State College Branch, East Lansing; University of Michigan Branch, Ann Arbor; luncheon for Counselors of these Branches, Detroit

Missouri

St. Louis Section; luncheon meeting of St. Louis Section Executive Committee with Counselors and Chairmen of University of Missouri, Washington University, and Missouri School of Mines Branches, St. Louis; Washington University Branch, St. Louis; Kansas City Section and University of Kansas and Kansas State College Branches, Kansas City

Montana

Montana Section, Butte

New York

Joint meeting of Student Branches in New York City District, New York, with ten Branches represented; New York Section; Winter General Meeting, New York; Schenectady Section; Union College and Rensselaer Polytechnic Institute Branches, Schenectady; Syracuse Section; University of Syracuse Branch; Rochester Section; Ithaca Section with Binghamton Area Subsection; District 1 Executive Committee, Schenectady

North Carolina

North Carolina Section and University of North Carolina and Duke University Branches, Raleigh

Ohio

Toledo Section; Dayton Section; Columbus Section and Ohio State University Branch; Cleveland Section, Case Institute of Technology Branch, and Fenn College Branch, Cleveland; Mansfield Section; Akron and Canton Sections joint meeting, Akron; University of Akron Branch; Cincinnati Section and University of Cincinnati Branch

Oregon

Portland Section; Oregon State College professors of electrical engineering, Corvallis

Pennsylvania

University of Pennsylvania and Drexel Institute of Technology Branches, Philadelphia; Philadelphia Section; Lafayette College Branch, Easton; Lehigh University Branch, Bethlehem; Lehigh Valley Section, Reading; Pittsburgh Section and Carnegie Institute of Technology, University of Pittsburgh, West Virginia University, and Pennsylvania State College Branches, Pittsburgh; Erie Section; I.S.A. Convention joint with AIEE Committee on Instruments and Measurements, Philadelphia; Johnstown Subsection

Tennessee

Memphis Section

Texas

South West District Meeting, Dallas

Utah

Utah Section and University of Utah Branch, Salt Lake City

Vermont

North Eastern District Conference on Student Activities, Burlington

Virginia

Virginia Section with Western Virginia Subsection and Virginia Polytechnic Institute and Virginia Military Institute Branches and professors representing the University of Virginia Branch, Roanoke

Washington

Richland Section; Seattle Section; Pacific General Meeting, Spokane

West Virginia

West Virginia Section, Charleston

Wisconsin

Midwest General Meeting, Milwaukee

ANNUAL MEETING

The 65th annual business meeting of the Institute was held in Mexico, Federal District, Mexico, June 23, 1948. The annual report of the Board of Directors for the fiscal year which ended April 30, 1948, was presented in abstract by Secretary H. H. Henline, who also presented reports of the Committee of Tellers on the vote of the membership on constitutional amendments, and on the election of officers whose terms were to begin on August 1, 1948. In the absence of Treasurer W. I. Slichter, his report on Institute finances was presented by Secretary Henline. President-Elect Everett S. Lee was introduced, and responded with a brief address. Institute prizes for technical papers were presented.

The Lamme Medal for 1947 was presented to Past-President A. M. MacCutcheon, retired Vice-President of the Reliance Electric and Engineering Company, Cleveland, Ohio. The president's address was delivered by Blake D. Hull.

GENERAL MEETINGS

Four general meetings were held during the year, and a brief report on each follows.

Summer General Meeting. The 64th Summer General Meeting was held in Mexico, Federal District, Mexico, June 21–25, 1948, with a registration of 1,074. The program included the special opening inauguration ceremony presided over by President Miguel Aleman of the United States of Mexico, 19 technical sessions, 2 administrative conferences, and the official annual business meeting of the Institute. Social and entertainment features included a banquet Monday noon sponsored by the Secretary of National Economy and by the Federal Commission of Electricity, at which about 1,300 persons were present by invitation; a reception and luncheon in honor of the Board of Directors; a banquet and grand ball; a symphonic concert; exhibition of Mexican dances; ladies' events; and closing ceremonies and reception.

Pacific General Meeting. The Pacific General Meeting was held in Spokane, Wash., August 24–27, 1948, with a registration of 375. There were a general session, seven technical sessions, two Student sessions, a meeting of the District 9 Executive Committee, a luncheon conference on Student activities, and an informal meeting of Section officers of Districts 8 and 9. Members and guests attended a luncheon meeting of the Spokane Chamber of Commerce on Tuesday, addressed by President Lee, and a joint luncheon with the Associated Engineers of Spokane was held on Wednesday. Other events were inspection trips, a golf tournament, ladies' entertainment, president's reception and dance, and a banquet.

Midwest General Meeting. The second annual Midwest General Meeting was held in Milwaukee, Wis., October 18–22, 1948. The registration was 1,507. The program included an opening general session, addressed by Mayor Frank P. Zeidler of Milwaukee, and President Everett S. Lee, and 34 technical sessions and conferences, with 125 papers of wide variety in the fields of power, industry, communication, and basic sciences. There were about 30 com-

mittee meetings and luncheons. Many members and guests attended a luncheon in the Allis-Chalmers clubhouse Tuesday. Other events included inspection trips, a stag-smoker with entertainment, a banquet and dance, an extensive ladies' program, and a "Gemuetlichkeit."

Winter General Meeting. The Winter General Meeting was held in the Hotel Statler, New York, N. Y., January 31–February 4, 1949, with a registration of 2,896, and a record program of 55 technical sessions and conferences, and presentation of 233 papers. In a general session, the Edison Medal for 1948 was presented to Dr. Morris E. Leeds, Chairman of the Board, Leeds and Northrup Company, Philadelphia; an address on "The Professional Estate" was delivered by Charles E. Wilson, President of the General Electric Company; and President Everett S. Lee gave an address on "Our Institute." Approximately 80 meetings of technical and administrative committees were held. In addition, there were inspection trips, a smoker, a dinner-dance, and ladies' entertainment events.

DISTRICT MEETINGS

Middle Eastern District Meeting. The largest meeting ever held by the Middle Eastern District was held in Washington, D. C., October 5–7, 1948. The registration was 715. In 20 technical sessions, 70 technical program and District papers were presented. In a general session, addresses were given by President Lee, and Dr. F. B. Silsbee, Chief of the Division of Optics and Electricity of the National Bureau of Standards. Dr. Silsbee was introduced by Past-President William McClellan, honorary Chairman of the Meeting Committee. The program included inspection trips, a smoker, a dinner-dance, and events for the ladies.

Southern District Meeting. A Southern District Meeting was held in Birmingham, Ala., November 3–5, 1948, with a registration of 334. The program included an opening session with addresses by the Honorable Cooper Green, President of City Commission of Birmingham, F. B. Weiss, Chairman of the Meeting Committee, President Everett S. Lee, and Vice-President J. H. Berry, who were introduced by H. J. Scholz, Chairman of the Alabama Section. In five technical sessions, many papers of particular interest in the South were presented. There were inspection trips, two banquets, a District Executive Committee meeting, and ladies' events.

South West District Meeting. A highly successful meeting was held in Dallas, Tex., April 19–21, 1949, with a registration of 783, including slightly more than 300 students. The features included two general sessions, one with addresses by President Lee and Dr. Jack T. Wilson, and the other with five addresses on "The Electrical Engineers' Contribution to the Growth of the Southwest," a meeting of the Board of Directors, seven technical sessions with 27 papers, two student sessions, two luncheons, a smoker and buffet supper, a banquet and dance, inspection trips, and ladies' events.

SPECIAL TECHNICAL CONFERENCES

A special technical conference is a relatively new type of meeting, which is held independent of general and District meetings. It may be defined as a program of panel discussions, technical papers, or exhibits under the auspices of a national technical committee in co-operation with an AIEE local Section. The purpose of these meetings is to expand technical committee activities on individual specialized subjects and to serve the interest of members and nonmembers on that subject. The scope of the conference is meant to be national in interest, technical in character, and concentrated as to subject matter toward one particular industry or objective. It also is intended to further the program of expanded Institute activities by taking the Institute to members, and at the same time to stress its potential value in advancing the AIEE into new fields by demonstrating in a forceful manner to engineers inside and outside the membership that the Institute does have a place for all, and is definitely interested in providing ways and means for discussing and ironing out their technical problems.

Operating under the foregoing principles, the following conferences were held during the past fiscal year.

Conference on Electric Welding was held in the Rackham Memorial Building, Detroit, Mich., December 6–8, 1948, sponsored by the Committee on Electric Welding, in co-operation with the AIEE Michigan Section, the Detroit Section of American Welding Society, and the Industrial Electrical Engineers Society of Detroit. The conference provided an opportunity for the presentation of papers and discussions among an audience of persons primarily interested in arc and resistance welding. The program was planned to cover many timely and vital topics of interest to manufacturers, designers, users, and the utilities which supply the power. Six sessions provided for the presentation of 31 papers. The total attendance at the conference was 436; advance registration was 178. Orders for proceedings at the conference were 235. A special inspection trip was planned to the Ford Motor Company's River Rouge Plant, and was attended by 194 persons. During the 3-day conference, 336 persons attended the special luncheons.

Conference on Electronic Instrumentation in Medicine and Nucleonics was held in the Engineering Societies Building, New York, N. Y., November 29–December 1, 1948, sponsored jointly by committees of AIEE and the Institute of Radio Engineers. Committees included the Subcommittee on Nucleonic Instrumentation of the Committee on Nucleonics and the Subcommittee on Electronic Aids for Medicine of the Committee on Electronics; also the Committee on Nuclear Studies of the Institute of Radio Engineers. These three groups found an area of common interest, and combined their efforts to conduct an interesting and informative conference. The program was planned to interest the several groups of technical specialists: one day for papers of interest to medical people, one for engineers and physicists, and another combined the interests of both medical and technical people. Six sessions provided for the presentation of 26 papers. The total attendance at this conference was 547 persons; advance registration 250. An interesting exhibit of nuclear radiation instruments, which was provided by the Atomic Energy Commission, accompanied this conference.

Conference on High-Frequency Measurements was held in Washington, D. C., January 10–12, 1949, sponsored jointly by the AIEE, the Institute of Radio Engineers, and the National Bureau of Standards. It brought together those interested in high-frequency measurements and measuring apparatus. The program was planned to include surveys of various branches of the art and the presentation of the latest developments in measuring technique. Four sessions provided for the presentation of 25 technical conference papers. The total attendance at this conference was 584; advance registration more than 200.

In addition to the technical sessions, inspection trips were arranged to the Naval Research Laboratory, the Naval Ordnance Laboratory, and the National Bureau of Standards. At a special luncheon at the Roger Smith Hotel on January 11, the guests were addressed by President Everett S. Lee, Dr. Stuart L. Bailey, President of IRE, and Dr. E. U. Condon, Director of the Bureau of Standards, each expressing the belief that many benefits to all and encouragement for future progress would be derived from the exchange of technical knowledge at these conferences.

Conference on Industrial Application of Electron Tubes was held at the Statler Hotel, Buffalo, N. Y., April 11 and 12, 1949. This conference was sponsored by the Subcommittee on Electron Tubes of the Committee on Electronics, and the Subcommittee on Electronic Control of the Committee on Industrial Control, jointly with the Niagara Frontier Section. The conference provided an opportunity to discuss the application of electron tubes in the industrial field, with presentation and discussion encouraged among the audience of people primarily interested in the application and operation of tubes in this field. A program was planned to cover experiences of manufacturers, designers, and users. Four sessions provided for the presentation of 20 papers. The total attendance was 229; with an advance registration of 152. Orders for proceedings at the conference were 118.

A special inspection trip was planned to Westinghouse Electric Corporation's Motor and Control Plant in Buffalo. A portion of the control division of this plant is devoted to the manufacture of electronic control equipment. The Monday evening dinner featured an address on the control aspects of atomic power by Dr. Karl H. Kingdon of the General Electric Company.

Conference on Electrical Engineering Problems in the Rubber and Plastics Industries was held at the Hotel Portage, Akron, Ohio, April 26, 1949, sponsored by the Subcommittee on Rubber and Plastics of the Committee on General Industry Applications, in co-operation with the Akron Section. This conference provided an opportunity for the presentation of papers and discussions of electrical problems in the rubber and plastics industry. Two sessions provided for the presentation of ten papers, with full discussion at the end of each session. The total attendance at this conference was 191; with an advance registration of 168. Orders for proceedings at the conference were 99.

Because of the lack of time at the one-day

conference, the committee was unable to schedule any special events except the noonday luncheon. For next year's conference, the committee is hoping to extend the time to two days in order to cover more fully the problems at hand. This was the second conference conducted by the committee on this subject.

General Committees

FINANCE COMMITTEE

The fiscal year ending on April 30, 1949, as was indicated by preliminary figures, shows an operating deficit of about $18,000. This shortage, together with temporary needs for cash during the latter part of the year, has been met by withdrawals from the reserve capital fund. These transfers will be repaid early in the new fiscal year. Certain remedial factors are now in operation, which, it is hoped, will minimize or obviate such transfers in the near future. They were reflected in the adoption in October 1948 of a balanced budget for the year October 1, 1948, to September 30, 1949; and performance under this budget so far has been approximately in line with its provisions. Principal among these remedial factors are

1. Substantially increased advertising rates in *Electrical Engineering*.
2. Establishment of registration fees for general and District meetings.
3. Price scales for Institute publications designed to make them approximately self-supporting.
4. Wholehearted co-operation by those committees responsible for sizable expenditures in the effort to confine their expenditures within limits set by the budget.

In spite of these encouraging signs, the financial future of the Institute is by no means a clear picture, and the Special Committee on Institute Dues appointed a year ago by President Hull is continuing to function. In response to one of its recommendations, the principal spending committees have submitted 5-year forecasts of their financial requirements, which now are being studied by the Finance Committee with the objective of preparing a 5-year budget. The special committee then will use this and other information to assist it in recommending a policy concerning the dues situation. In the meantime, the existence of the reserve capital fund is the "shock absorber" which enables our activities to continue unimpaired and to be enlarged where necessary to meet the demands of the ever-enlarging electrical industry.

COMMITTEE ON PLANNING AND CO-ORDINATION

The committee held four meetings during the fiscal year, in August and October, 1948, February and April, 1949. It is expected that a meeting will be held during the Summer General Meeting.

Meetings. Consideration and approval was given to a number of Institute general and District meetings scheduled to be held during 1950, 1951, and 1952, at various locations. It has been found desirable to schedule these at least two, and preferably three, years in advance in order to obtain suitable hotel accommodations.

Registration Fees. The matter of registration fees to be charged at general and District meetings has been reviewed at various times. A fixed schedule of fees was adopted in 1948, whereby, at general meetings members pay a registration fee of $3 and nonmembers $5, while at District meetings members pay $2 and nonmembers $3. Families of members and Student members are not charged any registration fee. The purpose of these fees is to assist in defraying the expenses of the technical activities of the meetings. Recently the Committee on Planning and Co-ordination reviewed this situation to determine what fees, if any, should be paid by guest speakers, nonmembers presenting papers, applicants, and so on. The committee recommended, and the Board of Directors approved, the following supplemental schedule:

Guest speaker—No fee.
Nonmember presenting paper—Nonmember fee.
Applicant for membership—Member fee.
Attendance at meetings jointly sponsored with other societies—Fees are to be agreed upon beforehand with the other society, either a each society charging its members according to its own rules, or b all in attendance being charged in accordance with AIEE rules; means of identification to be agreed upon.
Attendance at social functions only—No fee.

From all reports, the charging of registration fees during the past year has not aroused any substantial adverse criticism, and the money so collected has been decidedly beneficial in assisting to maintain a balanced budget.

Technical Activities. The Technical Activities Subcommittee has well served as the correlating agency of the several co-ordinating committees, and has handled a number of specific projects, including the preparation of "Administrative Scope for Technical Co-ordinating Committees" and a manual for technical conferences.

Several organization changes have been arranged for in the co-ordinating and technical committee setups. Several important subcommittees have been elevated to full committee status, and this has proved advantageous. The co-ordination group on Communication and Science has been enlarged and split into two co-ordinating groups, Communication, and Science and Electronics. The Communication Co-ordinating Group will have seven technical committees, and the Science and Electronics Co-ordinating Group will have eight technical committees.

The scopes of several new technical committees now are being prepared.

Professional Group. The Professional Activities Subcommittee has provided a scope for the Bylaws for the Committee on Education, which recently was transferred to the list of general committees and placed under the Professional Group Co-ordinating Committee.

Legislation and Tax Status. The committee has given a great deal of consideration to the tax status of the AIEE as it might be affected by activities in the field of legislation pertaining to engineers. The New York State Tax Department recently ruled the Institute to be exempt from New York State Unemployment Tax.

Uniform Grades of Membership. The committee has endorsed the statement of uniform grades of membership as adopted by the ECPD committee on Professional Recognition, and this has been approved by the Board of Directors.

Volta Memorial Fund. A specific procedure for handling this memorial fund was drafted, and it is expected this will be submitted to the Board of Directors for approval at the June meeting.

Prize Awards. Action has been initiated for a detailed review and analysis of the Institute's procedure for handling prize awards.

Technical Conferences. The policy to be followed in planning and conducting technical conferences has been discussed in detail, and the manual which is being prepared on this subject is expected to facilitate and encourage holding of such conferences, which have proved to be highly successful.

PUBLICATION COMMITTEE

The publication policy, which became effective January 1, 1947, has been continued in operation. This policy provides for three publications: *Electrical Engineering*, *Transactions*, and *Proceedings*, together with advance photographic copies of papers regularly approved for presentation at meetings. Each of these publications was described briefly in an article entitled "AIEE Publication Services Reviewed for Membership" (*EE, Apr '49, pp 348-9*), with a detailed statement telling how each publication might be procured. The number of pages of published material is reported in Table I for the calendar year 1948, so that it readily may be compared with the amount of material published during previous years.

Electrical Engineering. With the growth of the Institute in numbers of members and Student members, the circulation of *Electrical Engineering* has increased steadily from an average of 40,375 copies for the preceding

Table I. Numbers of Pages of Published Material

	Electrical Engineering			Transactions Only		
Year	Technical Articles	News	Transactions Sections	Technical Papers	Discussions	Totals
1941	337	281	600	542	268	2,028
1944	246	214	738	493	231	1,922
1945	255	225	736	121	143	1,480
1946	285	315	832	254	120	1,806
1947	806	474		1,463*	153*	2,896
1948	832	395		1,815†	172†	3,214*

* Preprinted in 227 sections of AIEE *Proceedings*, except for a 17-page technical paper in *Electrical Engineering*.
† Preprinted in 247 sections of AIEE *Proceedings* requiring a total of 2,090 pages.

Table II. Classification of Articles in Electrical Engineering in Seven Broad Fields

	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
General interest			2		2						3		7
Educational						2		2		2	1	1	8
Scientific	3.5*	4	6	2	4	3	2	3	2		0.5*	2	32
Communication	0.5*	2	1	1					1	3	3	1	12.5
Power	2.5*	2	1	1	4	3	5	3		3		1	25.5
Industry	3.5*	1		2		2	1		4	1	0.5*	1	16
General applications	1.0	1				1		1	2	3	3	1	14
	11	10	10	8	9	11	8	9	11	11	10	7	115.0

* Half values assigned to articles which fall in two fields.

year, as compared with 47,800 copies for the current year, with an all-time high of 52,100 copies for the April issue. The increase in circulation, combined with a ten per cent increase in the cost of printing and an advance in paper prices has been partly offset by reducing the yearly content by 135 pages, and using a paper of slightly less weight. In Table II, is presented a classification of articles in *Electrical Engineering* in seven broad fields. By judicious selection of technical papers of broader interest, and by giving preference to the papers which are shorter (six pages or less), the table shows that about the same number of articles have been published in the last half of the year, under the reduced page budget, as was published during the first half of the year. On inquiry in various sections of the country, it has been reported that the 135 pages have not been missed.

In the selection of articles for each issue, an attempt has been made to carry one or two articles in each of the six broad fields shown in Table II. The increase in the numbers of communication, educational, and general appliance engineering articles in recent months has met with favor. As time goes on, the totals for each of these six broad fields will be more nearly proportional to the number of members in these fields of endeavor.

Advertising. The amount of advertising received has held up very well, and it is expected that the gross revenue will total approximately the $180,000 estimated at the beginning of the appropriation year. The 33⅓ per cent increase in rates, which became effective February 1, 1948, still has not been in effect for a sufficient time to derive the full gross revenue for the duration of the appropriation year. In view of the large circulation, and, after consideration of the circulation and rates of eight similar magazines, the committee thought the rates for *Electrical Engineering* were disproportionate. However, on recommendation of the advertising director, the committee agreed that now was not an appropriate time to raise the advertising rates further.

Transactions. Volume 67 of the 1948 *Transactions* has been made available in two parts—part I, which consists of 862 pages, contains the papers which were presented during the first half of the year, and it was made available last December. Part II, which consists of 952 pages, includes the papers which were presented during the last half of the year, the Board of Directors' report, and a complete index, was made available in May. In this way, half of the papers have been made available six months sooner, and the bulk of the volume has been reduced. On recommendation to the Board of Directors, the Student subscription rate to the *Transactions* has been raised to $5, the same as for members.

AIEE Proceedings. As an interim service to members who are specialists, and Student members only, single copies of the 1948 papers correlated with discussion, if any, have been made available in 247 sections to those filling out order forms published every few months in *Electrical Engineering*. Ten per cent of the papers are free to members and additional papers are available at ten cents each. In the case of Student members, there is no free allowance. A total of 6,295 orders for *Proceedings* were received during 1948. These orders average 8½ papers per order form, and represent a distribution of 53,500 copies. Most of the copies ordered are free copies, and the total receipts were $644. By publishing a reference on the cover of the April issue to the location of the *Proceedings* order form in the advertising section, 54 per cent more orders have been received during the first ten days than were received during the same interval for the December order form. At this date, it is not known whether the procedure has merely advanced the time for ordering the papers, or there has been a substantial increase in the number of orders.

Review of Publication Policy. The present publication policy is being reviewed, a number of suggestions and constructive criticisms have been received from members and officers, and all of them are being given careful study. Among them, two important suggestions are listed:

(*a*). To abandon the *Proceedings* entirely and issue quarterly *Transactions* with the papers correlated in six subject divisions: communication, electronics and science, power systems, power equipment, general applications, and industry. This plan involves providing one or two such *Transactions* each quarter to each member without charge, and with a nominal price for any others. According to a preliminary estimate, one free division would cost approximately $3,700 less than the present cost of *Proceedings* and *Transactions*. Two divisions free would cost approximately $22,000 more.

(*b*). As an alternate to *a:* To publish more technical material in full in *Electrical Engineering* to the extent of the additional expense in *a*.

Special Publications. During the year, the following four special publications have been made available, and others are in prospect. These special publications fill a specialized need—they are published entirely on a self-supporting basis, and made available to members at cost, and in general at double the cost to nonmembers, through announcements published in *Electrical Engineering* from time to time.

1. Telemetering, Supervisory Control, and Associated Circuits (September 1948).

2. Electrical Engineering Problems in the Rubber and Plastics Industries.

3. Electron Tubes for Instrumentation and Industrial Use.

4. Elements of Nucleonics for Engineers.

Preprints. Technical papers approved for presentation at meetings have been made available in advance by a photolithographic process. A few of the papers not considered of permanent-record value have been made available as miscellaneous papers on an advance-copy-only basis. For the purposes of discussion, the free allowance to authors has been increased to ten copies, and the allowance to committees has been liberalized to 50 copies to the sponsoring committee. Other copies are sold to members at a price of 30 cents each, and to nonmembers at a price of 60 cents each. In general the system has been working satisfactorily, and it is believed to be more nearly on a self-supporting basis.

SECTIONS COMMITTEE

Section Activities. Section activities have continued to expand at accelerated postwar levels. A new Section has been formed at Miami, Fla., and several new Sections are in the process of formation. New Subsections have been formed in various Sections.

Booklet—"The Electrical Engineer." A subcommittee of the Sections Committee and of the Committee on Student Branches has revised the booklet, "The Electrical Engineer," and presented it to the headquarters staff for reprinting.

Prize Award Rules. A subcommittee of the Sections Committee has prepared a revision of the Institute Prize Paper Rules for final consideration at the June meeting of the Section Delegates. After approval, it will be presented to the Committee on Planning and Co-ordinating and the Committee on Award of Institute Prizes for final approval.

Meetings of the Sections Committee. A meeting of the Sections Committee was held during the Winter General Meeting. Three meetings are scheduled for Section delegates during the Summer General Meeting. These will include the Delegates' Get-together on Monday evening, June 20; a meeting to initiate an aggressive publicity program by the Sections on Tuesday morning, June 21; and a Section Delegates' Conference on Tuesday afternoon, June 21.

Co-operation With Other Institute Committees. The Sections Committee has actively co-operated with several Institute general committees, including Transfers, Membership, Student Branches, and the Technical Activities Subcommittee of the Committee on Planning and Co-ordination. At the request of the Technical Activities Subcommittee, a revised draft of the proposed policy on conduct of technical conferences was prepared and submitted.

Section Finances. A subcommittee of the Sections Committee under the chairmanship of G. W. Bower, Vice-President of District 2, is conducting a survey and study of the problem of Section finances for the next 5-year period. This study is being made in accordance with the action of the Board of Directors during the Winter General Meet-

Table III. Section and Branch Statistics

	For Fiscal Year Ending April 30					
	1944	1945	1946	1947	1948	1949
Sections						
Number of Sections	73	73	75	75	81	84
Number of meetings held	738	884	1,210	1,333	1,340	1,561
Total attendance	83,120	96,346	113,531	155,649	109,637	128,025
Branches						
Number of Branches	125	125	125	126	127	129
Number of meetings held	755	547	716	1,018	1,172	1,350
Total attendance	24,768	17,132	22,844	40,669	77,040	103,828

ing, wherein a recommendation of the Special Committee on Institute Dues requested a survey of Institute finances for the coming 5-year period.

COMMITTEE ON RESEARCH

The activity of the committee consisted of a symposium at the Winter General Meeting on the subject "New Tools for Research and What They Promise for Electrical Engineering." Several papers were presented, all of which were well received. Attendance was approximately 200. Plans for a similar session on a different subject are being formulated for the 1950 Winter General Meeting.

STANDARDS COMMITTEE

During the year, the administration of the Standards Committee was unfortunately interrupted by the untimely death of its Chairman, Dr. Reginald L. Jones, who had for many years past given tirelessly of his time and of his tremendously capable capacity.

The Secretary, H. E. Farrer, who served the committee exceptionally well for more than 25 years, was retired at the end of the calendar year 1948 under the Institute's retirement system, and has been succeeded in this assignment by J. J. Anderson, Jr.

In the field of Standards or Codes developed or revised, the past year saw the completion of the following: Industrial Control (revised); Marine Rules (further revision); Master Test Code for Temperature Measurement in Electric Apparatus; Graphical Welding Symbols; Mercury Arc Rectifiers (revision); Letter Symbols for Electrical Quantities; Transformers, Regulators and Reactors (revision); Steam Turbine Generators (revision); Speed Governing of Prime Movers (revision).

It has been determined finally between ASA and co-operating bodies that the size of published Standards will be changed to $8^1/_2$ by 11 inches, and for the AIEE this was put into effect during the year. New binders for the $8^1/_2$ by 11 size now have been provided, and the Institute's entire existing stock of Standards on hand have been repunched so they will fit both old and new binders.

A new Standards co-ordinating committee, designated as number 8, to be known as the Committee on Co-ordination of Insulation, has been formed under the chairmanship of J. H. Foote. This committee includes the entire AIEE delegation to the Joint Committee on Insulation between AIEE, Edison Electric Institute, and the National Electrical Manufacturers Association. The scope of this activity encompasses insulation levels, insulation strengths, apparatus design, and similar technical aspects.

The C40 Sectional Committee on Storage Batteries, one of the important ASA activities for which AIEE is sponsor, is being reactivated pursuant to getting at the revision of the storage battery Standards.

In the international field, a very successful conference session was conducted in Mexico City during the Summer General Meeting. Papers were presented outlining the standardization procedures employed in the United States, the use of Standards as tools by industry, emphasis on safety codes, and papers indicating the application of Standards to two specific types of apparatus. The entire top echelon of the Mexican Department de Normas participated in the conference, and were very cordial in conducting interested visitors through their facilities and in discussing together standards problems. Señor Rafael Illescas Frisbie, Director General de Normas, visited this country soon after the meeting, and it is believed a real forward step in understanding and co-operation was accomplished.

Further in the international field, the AIEE Committee on Marine Transportation was asked to assume international standards work in the marine field. Representatives thereof met in London.

One knotty problem entered into during the year and carrying over is that of temperature limits for switchgear in enclosures as controlled by cable insulation. This problem was assigned to a special subcommittee under the chairmanship of J. E. Clem.

UNITED STATES NATIONAL COMMITTEE OF THE INTERNATIONAL ELECTROTECHNICAL COMMISSION

Meetings of the following advisory committees of the International Electrotechnical Commission were held: A.C. 6: Lamp Caps and Holders, March 1948, The Hague; A.C. 28: Co-ordination of Insulation, June 1948, Paris; A.C. 18: Electrical Installations on Shipboard, July 1948, London; A.C. 30: Extra-High Voltages, July 1948, Paris; A.C. 31: Flameproof Enclosures, July 1948, London; A.C. 32: Fuses, July 1948, London. In Stockholm, Sweden, October, 1948—Council; Committee of Action; A.C. 6: Lamp Caps and Holders; A.C. 9: Electric Traction; A.C. 12: Radio Communication; A.C. 23: Electrical Accessories; A.C. 33: Capacitors.

The advisory committees have under way considerable technical work and much progress has been made. None of this work has resulted as yet in the submission of proposals for international agreement. Due to the lapse in the work during World War II, it is to be expected that some time will elapse before standard proposals can be put into shape for international adoption.

The meetings of the council and the Committee of Action were devoted to the administrative and financial affairs of the commission. Due to the transfer of the central office of the IEC from London to Geneva, Switzerland, during the previous year, adjustments were necessary. The offices in Geneva are now completely equipped and in a position adequately to service the work of the IEC. At Stockholm, work was actively begun on a revision of the Statutes, Rules of Procedure, and Directives for the Advisory Committees. The statutes were last revised in September 1913, and in the intervening years had become partially out of date. It is hoped that the revision of these fundamental documents of the IEC will be completed in the near future.

To date, a meeting of A.C. 14: Transformers, has been held in London, March 1949. The following meetings have been scheduled for the coming year: A.C. 32: Fuses, May 1949, Paris; and at Stresa, Italy, June 1949: A.C. 1: International Electrotechnical Vocabulary; A.C. 8: Standard Voltages and Current Ratings, High-Voltage Insulators; A.C. 10: Insulating Oils; A.C. 17: Switchgear; A.C. 22: Electronic Devices; Council; Committee of Action.

TECHNICAL PROGRAM COMMITTEE

Technical Programs. The technical activities of the Institute are at the highest level in history as a result of the efforts of 31 technical committees, the largest number ever to serve the Institute. The Winter General Meeting program was enlarged to provide for the presentation of 233 papers, 145 of which were conference papers. Both of these figures are new meeting records.

In Table IV, the number of papers presented at each of the seven meetings which were held during the year are given, together with the attendance. This table would show a greater increase in the yearly number of papers presented but for the fact that only half as many papers as usual were presented at the Summer General Meeting. One of the reasons for the smaller number of papers at the Mexico City meeting was the great amount of time required to provide preprints in both English and Spanish. The Mexican members were responsible for translating and reproducing the preprints in Spanish. The local members were most appreciative of having the papers available in their native language and, of course, the results were made available to a much larger number of engineers. The large number of sessions, conferences, and papers would indicate that the Institute is on its way toward a greatly expanded program of technical activities. This increase may be attributed to growth in membership and the increase in the number of technical committees from 21 to 31. In addition the Institute is served also by six joint subcommittees.

Planning for Programs. The recent creation of seven new technical committees has increased the number of these committees serving the Institute to a total of 38, which in itself will continue to make available to the Institute an increased number of technical meetings and papers. The committee

Table IV. Number of Papers Presented During the Year Ending April 30, 1949*

Meeting	District	Advance Copy Only	Conference Papers	Transactions	Total	Attendance
Summer, Mexico City		26		31	57	1,074
Pacific Coast, Spokane		2	11	19	32	375
Middle Eastern, Washington	33	8		29	70	715
Midwest, Milwaukee		10	57	58	125	1,507
Southern, Birmingham	17			1	18	334
Winter, New York		14	145	74	233	2,896
South West, Dallas	20	4		3	27	783
	70	64	213	215	562	7,684

* Repeated presentations not included.

now is reviewing papers for the Summer General Meeting, the meeting having been designed to fit in with the meeting of the American Society for Engineering Education to be held concurrently in Troy, N. Y. This kind of co-ordinated activity with other technical organizations also has added to the general activity in the electrical engineering field; each technical committee is attempting to work jointly, in so far as possible, with other technical bodies whose work affects it. In the arrangements of programs, an attempt has been made to cover all new developments in the field of electrical engineering and the allied arts. The geographical location of meetings also has been taken into consideration, and papers have been presented which were of particular interest in certain regions.

Analysis of Subject Matter. With special reference to the 1948 Summer General Meeting, the technical program was planned to present the latest trends and developments in a number of specialized fields of electrical engineering that were of particular interest to Mexican engineers. Among these were papers on paper and textile mills, petroleum and steel production applications, hydroelectric power and irrigation and mining operations. At the Pacific General Meeting, the emphasis was on transmission and distribution, while at the Middle Eastern District Meeting the larger number of papers were on subjects in the fields of air and marine transportation. A field relatively new to electrical engineers was covered at the Midwest General Meeting in a conference on ore beneficiation. Also presented, in the industrial field, was a symposium on speed regulating systems for sectional paper machine drives and an all-day conference on automatic contouring for machine tools. At the Winter General Meeting, a widely diversified program was highlighted by a conference on energy sources and symposiums on gas turbines for power generation and new tools for research.

Future Meetings. The program for the Summer General Meeting has been completed, and those for the Pacific General Meeting and the Fall General Meeting are well under way.

BOARD OF EXAMINERS

Statistics relating to the number of cases handled by the Board of Examiners during the year 1948–49 are given in Table V. The current total represents an increase of 60 per cent over 1947–48. These figures are exclusive of those covering "enrolled Students," which rose from 5,894 to 9,265, or about 58 per cent. The increase in the current total is principally in the applications for admission to the grade of Associate, this increase being 85 per cent.

Due to the increase in the membership of the Board of Examiners to 30, it has been possible to handle this larger volume of work with only one meeting over those regularly scheduled.

The large increase in Associate admissions and Student enrollments is principally due to the greatly increased enrollment in schools under the G. I. Bill of Rights. The Associate increase has come from those whose schooling was interrupted by the war and who have now finished the two or three remaining years. The Student enrollment has come largely from those who have taken advantage of the G. I. Bill of Rights to start their electrical engineering education.

There is need to re-emphasize the statement in last year's report to the effect that it is still necessary to ask frequently for more detailed statements of record and additional supporting references. A mere statement of dates and titles of positions held is not sufficient to enable the Board of Examiners to arrive at a decision on eligibility.

The Board of Examiners regrets the loss, through retirement, of its former Secretary, H. E. Farrer. His services to the Board through the years have been invaluable.

COMMITTEE ON CONSTITUTION AND BYLAWS

Submitted by the committee on June 2, 1948, and adopted by the Board of Directors on June 24, 1948, were the following recommendations:

Bylaws. A new section defining the scope of the Committee on Institute Publicity was added and became Section 78 in the 1948 "Year Book." The name was changed in October to Committee on Public Relations. Section 83 was amended to give the Standards Committee increased authority in the adoption of Standards.

A new section regarding the establishment of Subsections (or Divisions) was added, and became Section 41 in the 1948 "Year Book."

A new section relating to the disfranchisement of a Section of the Institute was added, and became Section 44 in the 1948 "Year Book."

Submitted by the committee on September 24, 1948, and adopted by the Board of Directors on October 19, 1948, were the following recommendations:

Bylaws. Section 105 (Section 107 in 1948 "Year Book") was amended to omit any reference to a limiting price for *Transactions*.

Sections 67, 69, 71, 72, 75, 81, 84, and the new section on Committee on Transfers (became Sections 66, 77, 82, 69, 74, 81, 80, and 86 in 1948 "Year Book") were amended to add the sentence, "At least one member of the committee shall be a member of the Board of Directors."

Submitted by the committee on January 20, 1949, and adopted by the Board of Directors on February 3, 1949, were the following recommendations:

Bylaws. A new section defining the scope of the Members-for-Life-Fund Committee was added, and will be placed between Sections 73 and 74, as printed in the 1948 "Year Book."

Section 31 was amended to clarify the matter of voting privileges of alternates to District Executive Committee meetings.

Submitted by the committee on March 29, 1949, and adopted by the Board of Directors on April 20, 1949, were the following recommendations:

Bylaws. Section 55 was amended to allow Student members to purchase current *Transactions* at the same price extended to members. A new section defining the scope of the Committee on Education was added, and will be placed between Sections 70 and 71, as printed in the 1948 "Year Book."

HEADQUARTERS COMMITTEE

The principal activities of the committee were the supervision of the cleaning of all rugs in the Directors' room, Members Room, and the hallways; shampooing of all upholstered furniture in these rooms; re-upholstering of three overstuffed chairs in the Directors' room, and repainting of all venetian blinds in both rooms; and the submission to United Engineering Trustees of a suggestion that AIEE participate in proposed changes in the first floor lobby of the Engineering Societies Building, and contribute proportionately to the cost of such changes on the basis that: AIEE retain its own Board room for meetings of Directors and other large groups, and AIEE make use of smaller rooms as necessary for meetings of small groups.

The committee has under consideration the matter of polishing the table in the Board of Directors room, and provision of a sectionalized glass top. Some further upholstering may be necessary during the coming year, and the possibility of new lighting fixtures in the Directors' room will be considered.

COMMITTEE ON PUBLIC RELATIONS

The Committee on Public Relations, formerly known as the Committee on In-

Table V. Applications for Admission and Transfer, 1948–1949

Applications for Admission		
Recommended for grade of Associate	4,061	
Re-elected to the grade of Associate	98	
Not recommended	3	
		4,162
Recommended for grade of Member	308	
Re-elected to the grade of Member	10	
Not recommended	73	
		391
Recommended for grade of Fellow	6	
Not recommended	2	
		8
Applications for Transfer		
Recommended for grade of Member	485	
Not recommended	38	
		523
Recommended for grade of Fellow	118	
Not recommended	4	
		122
Students		
Recommended for enrollment as Students		9,265
Total		14,471

stitute Publicity, has been guided in its activities during the past season by a statement of policy adopted by the Board of Directors during the summer of 1948. This statement reads in part as follows:

It is the policy of the Institute that public knowledge and understanding of the Institute's activities and public confidence in its members and their work be as widespread as possible. . . .

To accomplish these purposes and to promote the prestige of membership in the Institute, an active publicity program is necessary. Such a program should be integrated and continuous. It should reflect the Institute's position of responsible leadership in the scientific and engineering world and as the authoritative source of information regarding broad advances in the art of electrical engineering.

In former years the committee had as its principal duty the publicizing of the Winter General Meeting. To implement the Board's statement of policy, a program was undertaken which promises to widen greatly the public's appreciation of Institute activities. This program is based largely on active co-operation with Section officers throughout the United States.

Publicity for the Winter General Meeting again was handled by professional counsel, Raymond C. Mayer, who has served effectively in the past, provided press releases and services which resulted in broad news coverage. The Committee on Public Relations assisted as far as possible in the publicity activities of the local committee covering the South West District Meeting, and will assist in connection with the Summer General Meeting.

The program of "integrated and continuous" publicity has enlisted the lively support of the Sections Committee. As an experimental part of the program, a publicity kit of instructions, suggestions, and samples of written material has been distributed to the Sections for trial and comment. It is expected that experience with this material during the next year will lead to the exploration and improvement of means for co-operation between the Committee on Public Relations and the AIEE leaders throughout the country. A half-day session of the Sections Committee at Swampscott, Mass., will be devoted to the discussion of the kit and other phases of Institute public relations.

Plans to provide more active publicity for general and District meetings are also under way. A great deal remains to be done to carry out the Board's policy, but a good beginning has been made.

COMMITTEE ON SAFETY

The Committee on Safety has been active, both in holding a conference and meetings of importance to the Institute, and in launching projects for promoting a better appreciation of safety and for implementing safety into practice.

A project of outstanding importance which has been considered intensively throughout the year by the committee and by a special subcommittee is that relating to research on resuscitation from electric shock. Analysis of reports of electric shock accidents shows that about a third of the victims made unconscious, but given artificial respiration with the promptness that should promise success, fail to recover for causes generally unknown. The doubtful and unknown elements in this situation long have blocked any substantial improvement in the resuscitation ratio of shock victims. In this committee's considered opinion, this block will continue until removed by research.

A research program for this purpose, therefore, has been carefully drawn up by members of the committee, including engineering and medical authorities on electric shock. The three Schools of Engineering, Hygiene, and Medicine of the Johns Hopkins University have offered to carry out this research jointly if the necessary financial support can be secured. The program has the endorsement of the Accident Prevention Committee of the Edison Electric Institute. The carrying out of this research not only should provide information on reasons for present failures, but also explore promising improvements in methods of resuscitation. The Board of Directors of the Institute has endorsed this proposed research, and hopes the electrical industry can provide the necessary financial support.

During the year, the steering committee held numerous meetings for the purpose of preparing an authoritative pamphlet which would present the hazards of low-voltage electric shocks, how electrocution occurs, and the safety features of electrical codes in prescribing proper wiring and vigilant maintenance as means of mitigating the hazards of low-voltage shocks. The preparation of such a pamphlet which would be worthy of the dignity of the Institute was proposed at the 1948 Winter General Meeting as a means of aiding in the dissemination of information on electrical hazards and safety practices. Although its context is still in the formative period, the pamphlet is being pressed for early completion.

A comprehensive bibliography on safety is under preparation to supplement a prior edition which covered safety conferences up to 1942, and it is planned that it will be available during the next administrative year.

The committee has co-operated with the Sections and Student Branches Committees with the objective of promoting continuing interest in safety throughout the AIEE membership by the nationwide activities of these committees.

Various committee members gave addresses on pertinent phases of safety before AIEE Sections, chapters of the National Safety Council, meetings of the American Society of Safety Engineers, industrial accident prevention groups, electrical association meetings, and other technical groups. W. R. Smith, C. F. Dalziel, and W. B. Kouwenhoven have given addresses on different aspects of low-voltage shock hazards, and Robin Beach on electrostatic fire and explosion hazards in industry. Other members have been active in promoting safety within their respective organizations.

Several members of the committee were appointed to serve as liaison representatives with correlated committees of the Institute and with national organizations, such as, the American Society of Safety Engineers, Edison Electric Institute, National Fire Prevention Association, and others.

W. R. Smith, representing AIEE on the National Fire Waste Council, attended the annual meeting in Washington. The chairman, Robin Beach, represented the Institute on The President's Conference on Industrial Safety—being a member of the steering committee and of the Subcommittee on Machine Safeguarding. During the year, he attended three meetings of this conference in Washington. W. B. Kouwenhoven and W. T. Rogers, of the Committee on Safety, also attended the general conference meetings.

During the 1949 Winter General Meeting the Committee on Safety held a well-attended Conference on Control of Electrical Hazards in Rural Areas. The program included a treatise by Professor C. F. Dalziel on American and European practice in the manufacture and operation of electric fences and on the hazards of improvised or improperly designed systems. The papers on low-voltage shocks to cattle and to personnel on farm properties by W. B. Buchanan and J. H. Waghorne of the Hydro-Electric Power Commission of Ontario were reports of several years' investigations into this phase of the electrical hazards. A. H. Schirmer supplemented these papers on shock hazards arising from improper grounding by graphically presenting the code requirements for their elimination. These papers are being prepared for *Transactions*, as they summarize the findings from a long-range study, the collection of extensive field data, and recommendations for safe practices which possess outstanding value on this subject.

COMMITTEE ON TRANSFERS

The present Committee on Transfers has endeavored to continue the efforts of its predecessor committees in complying with the requirements of the bylaws calling for encouragement of the Sections in their local transfers work, co-operation with the Sections committees, acting as a medium of exchange of ideas, and working toward the preparation and maintenance of an operations guide for the local committees. Encouragement of and co-operation with the local Sections has been accomplished through answering all inquiries addressed to the committee and through issuance of a letter and questionnaire to all Section committees on transfers.

The committee met at the Winter General Meeting, at which time a clarification of the principles, policies, and objectives of grade transfer work was developed. These may be stated as follows:

1. Each member of the Institute should be in the highest grade for which he is qualified.

2. The impetus for transfer should come from without. No member should be overlooked. The initiative for advancing a man in grade preferably should come from his fellow engineers (although the prerogative to take the initiative himself should remain unimpaired).

3. The initiating and follow-through action for transfer best can be undertaken by each Section through the medium of a hard working standing Committee on Transfers.

4. Each Section committee on transfers should be, in effect, a "Junior Board of Examiners" undertaking the careful preliminary screening of each and all members of the Section.

Also on February 1, 1949, an informal report on transfers work was presented at a meeting of the Sections Committee.

The importance and status of Section committees on transfers cannot be overemphasized. There seems to be general agreement with the idea of Section committees on transfers having the status and importance of being in effect "Junior Boards of Examiners."

D. E. Moat, Chairman of the Committee on Transfers for the past two committee-years, perhaps has stated this conception

best in his report presented at the Summer General Meeting in 1948:

> The primary determination of when a member is qualified for a higher grade should be in the hands of the local committee on transfers. The procedure of trial application to the Board of Examiners should be abandoned except in borderline cases when for some peculiar reasons the local committee cannot decide.
>
> The Board of Examiners, of course, should be the last word, charged with the maintenance of the standards and quality of membership, but the local committee should be, in effect, a "Junior Board of Examiners" which nine times out of ten could come up with the recognized correct answer.
>
> The whole problem is one of definition placed in the hands of recognized people in each Section and which people should so clearly understand the requirements that they can fairly judge, approve, or disapprove, the qualifications of an applicant.

As an example, the Committee on Transfers of a Section having a membership of approximately 800 submitted 132 cases for transfer to the Board of Examiners over a two year period, of which only one case was disapproved.

A guide or manual of recommended procedure for Section transfer work is regarded as one of the most important objectives of the committee. Such a manual can be prepared best as the result of polling the Sections as to how past transfer suggestions have been received and acted on, and how the various Sections conduct their transfers work. From this information, the best material can be selected and combined into a master plan or manual of procedure. Toward this end, a questionnaire was sent to the Sections under date of March 18, 1949. In addition to questions as to committee procedures and suggestions, questions were included for the purpose of revealing the present extent and nature of Sections transfer activities throughout the Institute.

Other projects in which the Committee on Transfers is active are as follows:

1. Assistance in publicizing advantages of the higher grades.

2. Assistance in working toward improvement of the AIEE system of grades.

3. Improvement of proposal and application transfer forms.

Replies to the questionnaire are being currently received, and it is hoped that returns will be adequate to permit analysis and preparation of a proposed manual of procedure for presentation at the scheduled meeting of the committee at the Summer General Meeting.

In the letter of transmittal accompanying the questionnaire sent to the Sections on March 18, 1949, the following statements were included by way of encouragement to the Section committees on transfers:

> The importance of Section work on transfers cannot be overestimated. We, on the national committee on transfers, have come to regard a Section committee on transfers as a "Junior Board of Examiners," a "Court of Honor," sitting in accurate appraisal of a man's professional record in an endeavor to determine whether or not he merits the honor of advancement to a higher grade as a badge of recognition conferred on him by his professional associates. It is to be emphasized, however, that such a committee performs a screening function only, and in no way:
>
> 1. Replaces or changes the present constitutional procedure whereby the final decision as to whether or not an applicant qualifies rests with the national Board of Examiners.
>
> 2. Replaces the present right of individual members to take the initiative for their own transfer.

The committee's reaction from contact with the Sections over the past year is that interest in transfers work is very much on the increase throughout the Institute. The committee will continue to endeavor to move ahead in this very important work.

MEMBERSHIP COMMITTEE

Membership in the Institute increased by 2,391 members in the year ending April 30, 1949. This was the largest growth on record, amounting to 373 more than the previous maximum of 2,018 in 1946. Total membership reached 30,791. Table VI of membership statistics shows the nature of the changes in membership during the year.

Applications from new members shows the basis for the new records being set in Institute growth. Applications from Student members for Associate grade reached a new high of 2,286, compared with 1,481 in 1948. This trend of increased applications from students reflects the large enrollment in colleges, growth in Student membership, which reached a total of 19,428 as of April 30, 1949, and the active solicitation of students for election to Associate grade. See Table VII.

This trend of growth from the student group is still on the increase due to the fact that the peak graduation of electrical engineering students in the war-swollen cycle will not be reached before 1950 or 1951.

The accelerated activity of the membership committees among the college graduates tends to reduce the number of eligible members in other categories. This is reflected in the decrease in applications from all others in this fiscal year, as shown in Table VII.

Members in arrears for dues for the fiscal year ended April 30, 1949, reached a total of 1,376, compared with 1,288 last year. This represented a delinquency of 0.448 per cent, compared with 0.453 per cent a year ago, showing slight improvement. It is also encouraging to note that only 685 were dropped during the year, compared with 693 in the previous period.

Activity of the District vice-chairmen was outstanding during the year. From two to four letters were sent by each vice-chairman

Table VII. Number of Applications Received From Student Members and From All Others

Year Ending April 30	Students	All Others	Total
1949	2,286	2,192	4,478
1948	1,481	2,272	3,753
1947	938	2,331	3,269
1946	308	2,453	2,761
1945	249	2,179	2,428
1944	466	1,908	2,374
1943	783	1,431	2,214

Table VIII. Number of Student Members as of April 30

Year	New Applications	Renewals	Total
1949	9,967	9,461	19,428
1948	7,876	6,041	13,917
1947	5,092	3,929	9,021
1946	2,574	2,513	5,087
1945	2,326	2,287	4,613
1944	2,242	2,656	4,898
1943	2,512	3,200	5,712

Table IX. Record of AIEE Membership

Year	Total May 1	Year	Total May 1	Year	Total May 1
1884	71	1906	3,870	1928	18,265
1885	209	1907	4,521	1929	18,133
1886	250	1908	5,674	1930	18,003
1887	314	1909	6,400	1931	18,334
1889	333	1910	6,681	1932	18,003
1890	427	1911	7,117	1933	17,010
1891	541	1912	7,459	1934	15,230
1892	615	1913	7,654	1935	14,269
1893	673	1914	7,876	1936	14,600
1894	800	1915	8,054	1937	15,308
1895	944	1916	8,202	1938	16,078
1896	1,035	1917	8,710	1939	16,605
1897	1,073	1918	9,282	1940	17,213
1898	1,098	1919	10,352	1941	17,886
1899	1,133	1920	11,345	1942	18,944
1900	1,183	1921	13,215	1943	20,161
1901	1,260	1922	14,263	1944	21,407
1902	1,549	1923	15,298	1945	23,072
1903	2,229	1924	16,455	1946	25,090
1904	3,027	1925	17,319	1947	26,470
1905	3,460	1926	18,158	1948	28,408
		1927	18,344	1949	30,791

Table VI. Membership Statistics for Fiscal Year Ending April 30, 1949

	Honorary Members	Fellows	Members	6-Year Associates	Associates	Subtotals	Totals
Membership April 30, 1948	8	1,088	8,117	8,106	11,081		28,400
Additions							
New members qualified		5	249		3,009	3,263	
Former members re-instated or re-elected		4	96	64	134	298	
Subtotals		9	345	64	3,143	3,561	
Transfers		115	514	1,296		1,925	
Totals		124	859	1,360	3,143	5,486	
Deductions							
Died		36	71	68	33	208	
Resigned		2	46	110	119	277	
Dropped		2	75	232	376	685	
Subtotals		40	192	410	528	1,170	
Transfers			115	419	1,391	1,925	
Totals		40	307	829	1,919	3,095	
Net Changes		84	552	531	1,224	2,391	
Membership April 30, 1949	8	1,172	8,669	8,637	12,305		30,791

Table X. Deaths of AIEE Members Reported in Electrical Engineering

Name	Date of Election	Date of Death	Grade at Death	Obituary Notice in Electrical Engineering
Adams, Lee F.	A '09	Oct. 14, '48	F	Dec. '48, p. 1217
Adamson, Ralph T.	A '44	Mar. 19, '48	A	June '48, p. 613
Archibold, William K.	A '94	Oct. 27, '48	M	Dec. '48, p. 1219
Atwater, De Nyse W.	A '34	Apr. 13, '48	A	June '48, p. 613
Bachman, Elwood	M '40	Dec. 14, '48	M	Mar. '49, p. 271
Baker, Carey W.	M '34	July 5, '48	M	Sept. '48, p. 920
Bancroft, Charles F.	A '95	Oct. 25, '48	F	Dec. '48, p. 1219
Barrett, Sampson K.	A '11	Dec. 23, '48	M	Mar. '49, p. 269
Bassett, Allen	A '23	Nov. 19, '47	A	May '48, p. 503
Becker, Alvin G.	A '47	Oct. 18, '48	A	Jan. '49, p. 79
Bergrun, Ted	A '44	Apr. 1, '48	A	June '48, p. 613
Bijl van der, Hendrik J.	M '17	Dec. 2, '48	M	Feb. '49, p. 177
Bonine, Charles E.	A '03	Oct. 25, '48	M	Dec. '48, p. 1218
Booth, William T.	A '03	Apr. 11, '48	M	Aug. '48, p. 791
Borden, Stephen W.	M '16	May 13, '48	M	Aug. '48, p. 791
Bowman, Sr., James C.	A '40	June 30, '48	M	Sept. '48, p. 920
Brainerd, Frank K.	A '08	Dec. 6, '48	F	Feb. '49, p. 177
Buell, Henry H.	A '11	Jan. 12, '48	M	May '48, p. 503
Burkholder, Charles I.	A '03	Mar. 13, '48	F	June '48, p. 612
Cadwallader, James A.	A '15	Dec. 20, '48	F	Mar. '49, p. 270
Carr, John O.	A '22	Aug. 24, '48	A	Dec. '48, p. 1219
Champlin, Franklin J.	A '20		A	Nov. '48, p. 1115
Chipperfield, John W.	A '22	Mar. 16, '48	M	June '48, p. 613
Colpitts, Edwin H.	A '11	Mar. 6, '49	F	May '49, p. 460
Colvin, Clare W.	A '12	Oct. 9, '48	M	Jan. '49, p. 79
Davis, Benjamin	A '39	Oct. 8, '48	A	Dec. '48, p. 1219
Day, George C.	A '45	Nov. 13, '48	A	Mar. '49, p. 271
Diamond, Harry	F '47	June 21, '48	F	Aug. '48, p. 790
Dubs, Ford H.	A '27		A	Jan. '49, p. 79
Durland, D. C.	A '08	Oct. 19, '48	A	Dec. '48, p. 1219
Elson-Dew, William	A '08	Dec. 16, '47	F	June '48, p. 613
Flood, Jr., Henry	A '10	June 17, '48	F	Aug. '48, p. 790
Forman, Alexander H.	A '16	June 30, '48	F	Sept. '48, p. 920
Frankenfield, Budd	A '07	Feb. 1, '48	M	June '48, p. 612
Garretson, Harry D.	A '07	Feb. 12, '49	ML	Apr. '49, p. 366
George, Frederick R.	A '13	June 1, '48	ML	Sept. '48, p. 919
Glanc, John G.	A '03		F	Aug. '48, p. 791
Gordon, Leslie B.	A '25	Apr. 8, '48	M	June '48, p. 643
Gosweh, William S.	A '07	June 13, '48	M	Sept. '48, p. 919
Gowan, Arthur J.	A '23	Aug. 17, '48	A	Dec. '48, p. 1219
Graf, Robert J.	A '11	Jan. 2, '49	A	Mar. '49, p. 271
Haar, Selby	A '07	Sept. 5, '48	M	Jan. '49, p. 79
Haller, Cecil E.	A '43	July 6, '48	A	Dec. '48, p. 1218
Hamlin, Edwin W.	A '35	Apr. 27, '48	M	July '48, p. 714
Hancock, Edward A.	M '38	Feb. 26, '48	M	May '48, p. 503
Herring, Edgar J. C.	A '29	Oct. 28, '48	M	Mar. '49, p. 271
Herron, James H.	M '35	Mar. 29, '48	F	Aug. '48, p. 790
Hill, E. Rowland	A '99	Aug. 25, '48	M	Dec. '48, p. 1217
Hill, Frederick W. L.	M '24	Jan. 12, '49	F	Mar. '49, p. 271
Horley, R. E. G.	A '21		A	Dec. '48, p. 1219
Hoseason, Donald B.	A '22	July 16, '48	M	Oct. '48, p. 1021
Humphrey, Clifford W.	A '03	July 6, '48	F	Nov. '48, p. 1115
Jackson, John P.	A '92	Apr. 2, '48	F	June '48, p. 612
James, Tudor C.	A '18	July 3, '48	M	Oct. '48, p. 1021
Jones, Archer K.	A '16	Sept. 6, '48	A	Dec. '48, p. 1219
Jones, Reginald L.	A '11	Jan. 14, '49	F	Mar. '49, p. 270
Kelsall, George A.	A '10	Jan. 4, '49	A	Mar. '49, p. 270
Kenyon, Otis A.	A '06	Feb. 3, '49	M	Apr. '49, p. 365
Knight, George L.	A '11	Mar. 27, '48	F	June '48, p. 612
Knouse, Walter E.	A '27	Dec. 4, '48	A	Feb. '49, p. 177
Lately, Harry N.	A '04	July 11, '48	F	Sept. '48, p. 920
Law, Raymond K.	A '47	Feb. 23, '49	A	Apr. '49, p. 365
Lawson, John E.	A '22	July 23, '48	A	Oct. '48, p. 1022
Lear, John E.	A '03	Aug. 17, '48	M	Nov. '48, p. 1116
Lee, Lloyd L.	A '46	Aug. 14, '48	A	Nov. '48, p. 1115
Linebaugh, Jesse J.	A '06	Aug. 2, '48	A	Nov. '48, p. 1116
Littler, Raymond G.	M '44	May 1948	M	Oct. '48, p. 1022
Long, Thomas H.	M '44	Jan. 18, '49	M	Apr. '49, p. 366
Mackenzie, Norman	A '43	Dec. 13, '48	A	Mar. '49, p. 270
Mahoney, Francis W.	A '09	Aug. 21, '48	M	Dec. '48, p. 1219
Manion, William J.	A '33	Feb. 18, '48	A	May '48, p. 503
Mapes, Leland R.	M '29	May 1, '48	F	Sept. '48, p. 920
Marti, Othmar K.	A '21	Feb. 15, '49	F	Apr. '49, p. 365
Martin, Allan F.	A '36	Mar. 2, '48	A	May '48, p. 503
Mason, Frank H.	A '10	Dec. 17, '48	A	Mar. '49, p. 270
Maurer, Keith L.	M '30	Feb. 23, '49	M	Apr. '49, p. 365
Meyers, Robert S.	A '37	Dec. 12, '48	M	Mar. '49, p. 270
Miller, Eugene H.	M '25	Mar. 12, '48	M	June '48, p. 612
Mills, John	A '11	June 14, '48	F	Aug. '48, p. 790
Milnor, Joseph W.	A '13	Mar. 30, '49	F	May '49, p. 460
Moloney, Thomas O.	A '12	Jan. 30, '49	F	Apr. '49, p. 366
Moritz, Charles J. H.	A '02	June 27, '48	F	Oct. '48, p. 1022
Moser, Matthew X.	A '25	Feb. 3, '49	M	Apr. '49, p. 366
MacFadden, Samuel P.	A '19	May 23, '48	M	Sept. '48, p. 920
MacGregor, Willard H.	A '97	Dec. 19, '48	M	Feb. '49, p. 177
MacMuray, Charles F.	A '13	Aug. 24, '48	A	Nov. '48, p. 1116
McClure, Earl	A '37	Sept. 2, '48	M	Dec. '48, p. 1218
McKearin, James P.	A '11	Apr. 24, '48	F	Aug. '48, p. 791
McKinney, Henry H.	M '47	Apr. 13, '48	M	Aug. '48, p. 791
McLean, William	M '42	Dec. 17, '48	M	Mar. '49, p. 271
Needham, Robert J.	M '23	Oct. 25, '48	M	Mar. '49, p. 270
Nill, Edwin P.	A '41	May 20, '48	A	Aug. '48, p. 791
Orwell, Albert E.	A '44		A	Mar. '49, p. 271
Peterson, Arthur P.	A '32	July 16, '48	M	Nov. '48, p. 1115
Post, Charles R.	A '39	Feb. 18, '48	A	June '48, p. 613
Powell, David A.	M '45	Dec. 19, '48	M	Mar. '49, p. 270
Powell, James A.	M '31	June 9, '48	M	Aug. '48, p. 790
Pratt, William H.	A '02	May 29, '48	F	Sept. '48, p. 919
Price, Bernard	A '10	July 9, '48	A	Dec. '48, p. 217
Puffer, William L.	A '93	Mar. 8, '48	F	June '48, p. 614
Rawkins, Herbert L.	A '30	Feb. 17, '48	M	May '48, p. 503
Reid, William E.	M '36	Jan. 23, '48	M	June '48, p. 613
Rentschler, Harvey C.	M '40	Mar. 23, '49	M	May '49, p. 460
Riggs, Arthur E.	M '16	Oct. 30, '48	F	Feb. '49, p. 177
Rockwell, Robert L.	A '13	Feb. 11, '48	M	May '48, p. 503
Rockwood, Jr., George H.	A '26		M	July '48, p. 715
Rushmore, Samuel W.	A '00	Aug. 16, '48	A	Dec. '48, p. 1218
Sah, Adam Pen-Tung	A '35	Feb. 14, '49	F	Apr. '49, p. 366
Samuels, Maurice M.	F '24	Jan. 29, '49	F	Mar. '49, p. 271
Shire, Leo E.	A '27	July 31, '48	A	Nov. '48, p. 1116
Sloan, Kenneth H.	A '38	Dec. 31, '48	M	Apr. '49, p. 365
Smeaton, James H.	A '07	Oct. 30, '48	A	Jan. '49, p. 79
Smith, Howard E.	A '44	Apr. 25, '48	A	June '48, p. 612
Smith, Jr., Walter F.	A '23	Feb. 9, '49	M	Apr. '49, p. 366
Snow, Wilber C.	A '20	May 20, '48	M	Dec. '48, p. 1218
Spencer, Charles G.	M '22	Aug. 16, '48	M	Nov. '48, p. 1116
Stayner, Charles M.	A '20	Nov. 19, '48	M	Mar. '49, p. 270
Sterne, William C.	A '23	Nov. 28, '48	M	Feb. '49, p. 177
Thompson, Jesse L.	M '40	Jan. 13, '49	M	Apr. '49, p. 365
Twyford, George T.	A '21	Dec. 6, '48	A	Mar. '49, p. 271
Unger, Arthur M.	A '40	Sept. '48	A	Dec. '48, p. 1218
Warren, Aldred K.	A '95	Nov. 20, '48	M	Jan. '49, p. 79
Watts, Frank W.	A '24		F	May '48, p. 503
Werwath, Oscar	A '19	Mar. 20, '48	M	June '48, p. 613
White, Peter	A '37	Dec. 12, '48	A	Feb. '49, p. 177
White, William M.	M '21	Feb. 9, '49	M	Apr. '49, p. 366
Wilson, Charles C.	M '43	Aug. 12, '48	M	Oct. '48, p. 1021
Wilson, Jr., Joseph C.	A '44	July 14, '48	A	Sept. '48, p. 920
Wilson, William	M '23	May 6, '48	M	July '48, p. 715
Wood, Albert C.	A '10	Mar. 13, '49	M	May '49, p. 460
Work, William R.	A '08	Oct. 3, '48	F	Dec. '48, p. 1218

to the Section membership chairmen suggesting ways of increasing membership and committee activities. In addition to this, the vice-chairmen made many personal visits to Sections encouraging membership work. All Districts showed a gain in membership applications except District 8. The greatest gain was 57 per cent by District 9, with District 7 close behind. District 7 showed the greatest activity per member, having applications totaling 21.1 per cent of the membership at the beginning of the period.

Individual membership committees are of course primarily responsible for these gains. The committees had more members on the average and were particularly active in handling personal contacts with prospects. The greatest difficulty is still in the delay in organizing committees. Few Section membership committees begin active solicitation before the first of the year, which leaves only four months of concentrated effort.

The new program for soliciting Associate applications from Student members before departure from college was inaugurated this year. It is expected that this will stimulate membership and aid the Membership Committees. This program was developed through the efforts of the Membership and Student Branches Committees.

Two active subcommittees are working on membership problems. J. C. Woods, Vice-Chairman of the Membership Committee, is acting as chairman of a joint subcommittee with the Committee on Student Branches to study Student membership in the Branches. It is expected that this group will recommend methods of increasing Student membership and standardizing practices among the various universities and colleges.

Walter C. Bloomquist, Vice-Chairman, District 1, is acting as chairman of a subcommittee to prepare a proposal for improving the function of interesting prospective members in the Institute. A revision of the "Membership Information" bulletin has been proposed.

The key to a successful membership promotion program still rests with the individual initiative of the Section membership chairmen. Earlier selection of committees, use of larger committees, and more

activity in finding and soliciting prospects are the three objectives to which each must strive. These committee chairmen have done an outstanding job this year but much ground is still to be gained in the year ahead.

Professional Group Committees

COMMITTEE ON CODE OF PRINCIPLES OF PROFESSIONAL CONDUCT

The committee has dealt with only two matters of importance, beyond incidental correspondence upon minor matters not requiring further attention. These were a new Statement or Code of Principles of Professional Conduct, and action of the Southwestern Power Authority, United States Department of the Interior, in soliciting competitive bids for engineering service.

In regard to the first matter, work held over from last year has continued upon the formulation of a formal Statement of Principles of Professional Conduct which will combine the newer Engineers Council for Professional Development canons, or ethical principles, with certain additional rules of practice which have had a long and honorable history in the Institute code.

The second matter involved a case where a Federal bureau advertised for competitive proposals for professional electrical engineering services. That matter was closed with our detailed report to the Board of Directors. It appeared that the bureau officials needed outside engineering service, but were advised that under existing law and regulations they had no other way of securing it. This committee found no violation of the new canons or the old code, but believed that the Institute should not approve or encourage such practice, and that necessity for it should be removed by legislative or executive action.

COMMITTEE ON EDUCATION

Four sessions have been individually or jointly sponsored at general meetings as follows.

1. At the Summer General Meeting, papers by two Mexican and three American authors dealt with education in Mexico, and with philosophical side of engineering education.

2. At the Midwest General Meeting, a conference was sponsored jointly with the Committee on Student Branches to promote interest among engineering students and faculties in electric power engineering. This activity was undertaken because the committees thought that students have been preparing for careers in electronics and communication in numbers proportionately much greater than employment opportunities warrant. Four papers, on careers in power engineering, unsolved problems, and better ways of teaching in the field were given to a large audience whose interest was exhibited by a spirited discussion.

3. At the Winter General Meeting, one conference was held on the theme "Industry's Active Part in Education." Four papers were presented, two from industry, two from educational institutions. The papers dealt with co-operation between colleges and industry at the undergraduate and graduate levels and with the development of the young engineer after entering industry. Another conference was sponsored jointly with the Subcommittee on electronic Education of the Committee on Electronics on the theme "Education in Power Electronics." Five papers were presented showing how the subject of power electronics could be employed to great advantage as a medium of instruction.

A session is planned for the Summer General Meeting on the accreditation of electrical engineering curricula. It is thought that the value of Engineers Council for Professional Development accreditation will be enhanced by a wider understanding of its objectives and procedures. At later meetings, it is planned to present and discuss other activities of the ECPD within the field of electrical engineering education. With these subjects and others, the committee looks forward to being able to sponsor interesting sessions at three of the general meetings each year.

At the invitation of the Engineers Council for Professional Development, the committee has undertaken a revision of Section IV, Electrical Engineering, of the ECPD Selected Bibliography of Engineering Subjects. The efforts of many members of the committee who have given generously of their time have brought this work very near to its completion.

In addition to these activities, the committee has considered and is currently considering other questions: the report of the President's Commission on Higher Education, industrial experience for foreign students, co-operation with Sections of the Institute in educational programs, and the acquainting of students with the facts of professional registration and licensing, the last jointly with the Committee on Registration of Engineers.

The committee thinks it can be most effective if it deals with problems that require the co-ordinated efforts of the engineering teacher, the practicing engineer, and industrial and governmental organizations. Thus, it is recommended that in appointing new personnel, there be more nearly equal representation from industry and colleges than at present.

COMMITTEE ON REGISTRATION OF ENGINEERS

The committee has continued its activities in connection with efforts to advise AIEE membership regarding the advantages of registration as a professional engineer and also as to the procedures for registration in the several states. Particular emphasis has been placed upon acquainting the young engineer, both while a senior in college and during his early years of professional activity, with professional registration.

Meetings of the committee were at the Midwest General Meeting and at the Winter General Meeting. Another meeting of the committee is scheduled for the Summer General Meeting, at which time special consideration will be given to suggested changes in the Model Law.

The committee has asked Professor R. W. Sorensen and Professor A. H. Lovell to prepare a paper entitled "Registered Professional Engineers." This paper has been prepared and presented for publication in *Electrical Engineering*, with the expectation of distributing several thousand copies to the Student Branches and the Sections of the Institute, calling their attention to professional registration, its advantages, and its procedures.

The committee has addressed a letter to each of the Student Branches, suggesting that they arrange a meeting at which the Sorensen-Lovell paper could be discussed, and at which time the Student membership could be given full information regarding registration. A letter also has been addressed to the officers of each Section of the Institute, directing their attention to the Sorensen-Lovell paper, and suggesting that they give all possible assistance to the Student Branches; also that some time be devoted at a Section meeting to acquaint the general membership with registration facts.

The individual Sections also have been asked to give assistance wherever possible to the State Boards of Examination, particularly in helping them to prepare suitable questions for the examinations covering the field of electrical engineering. Encouragement wherever possible has been given to the Sections to establish refresher courses to prepare their membership for the written and oral examinations.

At the suggestion of the committee, a question regarding the status of registration was included on the "Year Book" card circulated by AIEE headquarters to the membership. It is hoped that the returns will provide additional information regarding the extent of registration among our membership.

COMMITTEE ON STUDENT BRANCHES

During the past year, the Committee on Student Branches held three meetings, each at a general meeting of the Institute. At these meetings, there were unusually important agenda items which are summarized in the following.

At the committee meeting in Mexico City, a means of revising and expediting the timetable and processes of admission of Student members to Associate grade was recommended to the Board of Directors. This was the result of a study made jointly with the Membership Committee.

The committee met at the Midwest General Meeting. Pursuant to remarks made by Past President Hull and endorsed by President Lee, the committee set up a subcommittee to work jointly with the Institute of Radio Engineers to work out recommended bylaws for the establishment of Joint Student Branches that would be acceptable to both Institutes. The committee endorsed the action of the previous committee relative to using ECPD accreditation as a necessary qualification in the establishment of Student Branches in schools within the United States.

The third meeting was at the Winter General Meeting. At this time, the Subcommittee on Joint Student Branches reported in full and presented a model set of bylaws that had been worked out with IRE representatives. The committee endorsed this report, and referred it to the Secretary of the Institute for Board of Directors' consideration. This is an important step allowing many schools now having Branches to operate in a clearcut fashion jointly with many IRE branches now in existence.

At the New York meeting, a new joint

subcommittee was established with the Membership Committee and the Sections Committee. This group will organize and undertake surveys of Student Branch membership as a function of maximum potential membership at each school. It is investigating methods used by Counselors in promoting a larger percentage of admissions of Student Members as Associates, and will inquire concerning active steps taken by Branches to insure closer co-ordination with AIEE Sections located in the same geographical area.

The committee approved the revision of "The Electrical Engineer," which was accomplished jointly with the Sections Committee, and this revision was referred to headquarters for publication.

The Committee on Student Branches jointly sponsored with the Committee on Education a session at the Midwest General Meeting covering career opportunities, teaching methods, and growth in the electrical engineering power field. This session was very well received, and all of the four papers, each by an outstanding author, have been since published in *Electrical Engineering*.

During the past year, the committee has had referred to it seven requests for permission to establish new Student Branches. After complete consideration in each case, the committee recommended four for favorable consideration of the Board of Directors, and to date three charters have been approved. These Branches are located at the following schools:

Louisiana Polytechnic Institute

Fenn College

Instituto Tecnologico y De Estudios Superiores De Monterrey

Technical Committees

Co-ordinating Committees

POWER, INDUSTRY, COMMUNICATION AND SCIENCE, GENERAL APPLICATIONS

Organizational Changes. The technical committees have continued to function under four co-ordinating groups as established by the Board of Directors on April 23, 1947. It has been found that the co-ordinating committee meetings have been very valuable to the work in each group, and they have, to a considerable extent, facilitated the efforts of the individual technical committees. Problems relating to organization of technical committees received careful study by the co-ordinators, culminating in the following:

1. The Committee on Electronic Power Converters was transferred from the Power Group to the Communication and Science Group. This action was taken to reduce the number of technical committees within the Power Group from 12 to 11, also placing the committee in the group where it could carry out its work more effectively. At the same time, this change tended to equalize the number of committees within the co-ordinating groups. The creation of additional co-ordinating groups with the numbers of committees similarly limited will insure more effective operation under the co-ordinating group plan of organization.

2. A fifth co-ordinating group was created by splitting the Communication and Science Group into two groups, one for Communication and the other for Science and Electronics. This gives more prominence to Communication and Electronics, and elevates these subjects to positions commensurate with their importance in the field of electrical engineering.

3. The Metallic Rectifier Subcommittee has been advanced to full technical committee status. Upon recommendation of the Chairman of the Committee on Chemical, Electrochemical, and Electrothermal Applications of the Industry Group, this committee has been transferred to the Science and Electronics Group. It is believed that this arrangement will provide desirable liaison between the several technical committees of relatively common interests, since metallic rectifiers appear to have much in common with electronics and basic sciences.

4. The growing importance of servomechaniam applications would seem to indicate the need of a full technical committee on this subject, which currently is being handled by subcommittees of several technical committees. The matter has been under study, which will be continued during the ensuing year.

5. In accordance with a resolution by the Committee on Planning and Co-ordination to the effect

> "That it is the sense of the Committee on Planning and Co-ordination that the number of committees (11) in the Power Group may be too large for effective operation, and, therefore, the Power Group Co-ordinating Committee should give consideration to the desirability of dividing it into two groups,"

a letter ballot canvass was conducted among the members of the Power Co-ordinating Committee on the proposal to split the Power Group into two groups, one for Power Equipment, and the other for Power Systems. A majority favored the proposal, with a strong minority in opposition thereto. The matter remains unsettled, pending further study and consideration.

Committee Scopes. Experience during the year has demonstrated successful operation under the scope previously prepared for each technical committee. Accordingly, the policy of having scopes available for all committees at Institute headquarters was extended to include all subcommittees, working, and project committees.

Technical Conferences. The number of technical conferences on specialized subjects scheduled during this year has been greatly increased, and this development promises to become one of the more important Institute activities. A written statement on the policy with respect to technical conferences has been completed in the form of a manual for the guidance of technical committee chairmen who may plan to sponsor such conferences. The co-operation and contribution of J. C. Strasbourger, Chairman of the Sections Committee, toward completion of this project is gratefully acknowledged. Plans for joint sponsorship with IRE of annual technical conferences on semiconductors have been completed, with recommendation for approval of this undertaking pending.

Committee Publicity. With the April 1949 issue of *Electrical Engineering*, a new department was created titled "Committee Notes," the object being to provide publicity on technical committee activities, which it is hoped will be interesting and beneficial to the Institute members.

Power Group

COMMITTEE ON CARRIER CURRENT

The Committee on Carrier Current held three meetings. In addition to the committee meetings, a full technical session was sponsored at the Midwest General Meeting, and a combined technical and conference-type session at the Winter General Meeting. At these meetings, a total of four *Transactions*-type papers, three committee reports, and four conference-type papers were presented.

The following projects are being followed actively, or have been completed during the past year, as indicated by the individual listings in the following:

1. A project committee is preparing a general-interest paper covering the status of carrier current in power system operation.

2. A survey was made and a report presented in Milwaukee outlining the subject of methods of measurements at carrier frequency. Project completed.

3. A working group is collecting data on the carrier current characteristics of transmission lines and systems.

4. A working group is collecting information on the carrier current characteristics of power equipment.

5. A subcommittee has been appointed to prepare information that would permit writing an application guide for carrier-current equipment. A working group prepared and presented a report on coupling capacitors and traps for rural line carrier telephone applications. Work completed.

6. A working group prepared and presented a report on the use of microwave equipment for relaying, telemetering, and supervisory control. This study of the application of microwave equipment for power system uses will continue.

7. A working group has been appointed to obtain data as to the operating experience with carrier current channels with the intention of publishing a committee report indicating the expected reliability of such channels.

8. A subcommittee has been appointed to study the requirements for tubes for carrier current applications and to report from time to time on the status of this subject.

COMMITTEE ON INSULATED CONDUCTORS

This report covers the work of the committee, which until 1947 functioned on a limited basis as the Cable Subcommittee of the Committee on Transmission and Distribution.

Committee Meetings. Committee meetings have grown from 1- to 2-day sessions, the first portion being devoted to individual subcommittee meetings. The committee held two meetings during the past year with an average attendance of 47.5.

Subcommittee Organization. To effect functioning of this newly created committee it was organized into 12 standing subcommittees as follows: Administration, Standards and Publications, Cable Characteristics, Conductors, Insulations, Sheaths and Coverings, Cable Supply Systems, Utilization Wiring Systems, Special-Purpose Cable, Accessories, Structures, and Tests and Measurements. It is recommended that the standing subcommittee type of organization be continued. This plan is preferred to the project type because it is more productive of sponsored papers, which is one of the primary objectives of an AIEE committee. Also, it avoids the administrative detail and time lag involved in setting up new working groups as each project is suggested for study.

Technical Papers. The committee has reviewed a number of papers, and 11 were scheduled at meetings held during the past year. In addition, five papers will be on the program of the Summer General Meeting. The committee is making an effort to sponsor papers on topics neglected heretofore, or inadequately covered recently, and to include papers on engineering practices as well as on new developments in the art.

Standards. During the past 30 or so years the AIEE has not been a factor in the field of standards for either bare or insulated conductors. To some extent, this situation is attributable to the fact that, until 1947, the subject of conductors was not recognized with autonomous technical committee status. At present, the generally accepted major industry standards and specifications for conductors are sponsored by eight organi-

zations. It is evident that the AIEE plays a very minor role in standards for conductors, and will continue to do so unless there is a major change in policy by the established sponsoring organizations. Standards under consideration by the committee are as follows: Wires and Cables (AIEE 30–1944); Low-Voltage Air Circuit Breakers (AIEE 20A–1946); Recommended Practice Electric Installations on Shipboard (AIEE 45–1948); Potheads (AIEE 48–1948); Cable Limiters; and Test Code for Paper-Insulated Power Cables.

Subcommittee Projects. A project numbering system for the numerous activities of the subcommittees has been adopted. The advantages of this system are

1. Helps the chairman co-ordinate and follow the various subcommittee activities.
2. Assists the secretary in preparing co-ordinated and continuous issues of minutes.
3. Assists in the preparation of annual reports.
4. Tends to keep letters confined to one subject.
5. Provides an automatic filing system.
6. Helps to provide continuity of effort and to avoid repetition of work from one administrative year to the next with changing chairmen and personnel.

Numerous projects are being considered by the subcommittees.

Co-ordination With EEI and AEIC. To avoid duplication of effort, an informal working agreement was effected with the Edison Electric Institute and the Association of Edison Illuminating Companies. In general, it is based on the principle that in case of possible duplication the AIEE will not actively engage in the project, provided the EEI and AEIC intend to publish the results of their work. In some cases the publication facilities of the AIEE will be utilized for this purpose.

General. At the request of the Power Group Co-ordinating Committee, consideration was given to the formation of a Pacific Coast Subcommittee. However, it was decided not to organize this subcommittee, as few if any meetings could be held because of the distances involved. Since the participation in subcommittee work would be by correspondence in either event, it was thought preferable for the Pacific Coast members to be in contact directly with the subcommittees rather than through a Pacific Coast Subcommittee. Studies are being conducted through the subcommittees on many interesting and valuable projects.

COMMITTEE ON POWER GENERATION

Five technical sessions were sponsored by the Committee on Power Generation during the year. A total of 13 technical and 5 conference papers were presented at these sessions. In addition, the committee held two meetings during the year, the first at the Midwest General Meeting, and the second at the Winter General Meeting. Subjects covered by the papers were

1. Hydroelectric station design and operation.
2. Speed governing of multivalved steam turbines.
3. Speed governing of automatic-extraction steam turbines.
4. System load division by accurate time control.
5. Hydraulic model of liquid-cooled turbine-alternator rotor.
6. Outage rates of steam turbines, boilers, and hydro units.
7. Gas turbine design, theory, and testing.

At the last meeting, plans were laid to hold a technical conference on the subject of "Problems of Meeting Load Demands With Limited Reserve in Light of Maintenance and Forced Outages." Time and place of the proposed conference are to be settled later.

Activities of the committee are delegated to the subcommittees which reported as follows during the year:

Prime Movers. Two sessions on gas turbines were presented at the Winter General Meeting. Three technical papers and four conference papers were presented on different aspects of these new prime movers in respect to stationary power generation. Plans are under way to organize a joint committee with the American Society of Mechanical Engineers to consider the problem of standardizing steam turbogenerators, 7,500-kw capacity and under.

Speed Governing. During the year, the speed governing specifications that had been in trial use were recommended to be accepted for standard practice. One session at the Midwest General Meeting was sponsored to present two papers on speed governing, one paper on load division, and one paper on liquid-cooled rotor. Four papers on speed governing are being organized for the Fall General Meeting.

Station Design. A session of two or three papers on station auxiliaries is being organized for the Summer General Meeting. A program of papers for the Winter General Meeting, 1950, is being planned on the subject of centralized control in generating stations.

Excitation Systems. Two papers had been initiated by this group during the year and presented at jointly-sponsored sessions held during the Winter General Meeting. The working group on definitions has produced about 12 definitions relating to excitation systems. These will be presented to ASA Committee *C-42* for consideration and inclusion in its project on electrical definitions.

Application of Probability Methods. Outage data on steam and hydro-units collected under the auspices of the Edison Electric Institute have been published by the AIEE as a project of this subcommittee. A bibliography on probability methods is being compiled as well as a collection of definition of terms. A survey is under way of the load scheduling methods and spinning reserve practices being used by various utility systems in the United States. Papers are being solicited for the 1950 Winter General Meeting on the development of short-cut methods in probability calculations and on the probability of forecasting errors.

Hydroelectric Systems. Seven papers were presented at the Summer General Meeting, and at the Pacific General Meeting. Three papers are in preparation or available for future meetings.

Pacific Coast. A paper describing the available test procedures for determining performance of large hydroelectric turbogenerator units will be solicited. Plans are being made to collect statistical data on electrical characteristics of recently installed hydro generators feeding extensive high-voltage long-distance transmission systems. It is intended to make qualitative and quantitative analyses of these data and to determine the reasons for selecting the various characteristics.

COMMITTEE ON PROTECTIVE DEVICES

The activities of the committee, carried on by three subcommittees, were as reported in the following.

Fault Limiting Devices Subcommittee. The "Application Guide for the Grounding of Synchronous Generator Systems," will deal with the different methods of grounding synchronous generator systems, such as unit, more than one generator on a bus without feeders, generators on a bus with feeders, and so forth. It will discuss the various methods of grounding, such as potential transformer, distribution transformer, resistance, reactance, and direct grounding. The basic considerations in grounding will be discussed, and the accepted and preferred methods will be summarized with the advantages and disadvantages of the various methods pointed out. It is expected that the guide will be presented at the Fall General Meeting.

The "Application Guide for the Grounding of Transmission Systems," will deal with the basic factors and the different methods of grounding transmission systems of 22 kv and above. It will present the acceptable methods of providing grounding connections on transmission systems. It discusses in general terms ground relaying, limitation of ground fault currents, arrester protection, and transient overvoltages. Grounding transformers, grounding reactors, grounding resistors, and ground fault neutralizers are reviewed with regard to their proper application. This guide is intended to summarize briefly those methods of grounding transmission systems which are considered to be best practice.

The "Guide for Application of Ground Fault Neutralizers," reviews the voltage, current, frequency, and time ratings of ground fault neutralizers, application criteria dealing with location and number of units, system insulation levels, electric-static balance to ground, system interconnections, and possible effect on loading of transformers. Operating information dealing with tuning and testing after installation is discussed. It is expected that the guide will be presented at the Fall General Meeting.

The "Bibliography of Literature on Grounding Devices," will be divided into two parts: Bibliography on Resonant Grounding (Neutralizer Grounding), which will be complete through 1947 for presentation at the Fall General Meeting, and Neutral Grounding Devices in general, which is still incomplete, with no definite indication as to its completion date.

The "Field Survey of Unbalanced Charging Currents," is intended to determine whether the unbalanced charging currents of transmission lines were sufficiently large to justify the requirements in the AIEE Standard for Neutral Grounding Devices, which requires the ability of ground fault neutralizers to be capable of carrying 30 per cent circulating current continuously. This survey has been completed and the results will be presented at the Fall General Meeting.

The "Power System Fault Limitation" report is being prepared on methods used to limit fault currents on a metropolitan underground system; a system composed of overhead transmission and use of series reactors. With the increases in generating, transmission, and distribution facilities that are being made, it is important to limit the short-circuit kilovolt-amperes to a reasonable value. This is true both from the standpoint of the installation of new equipment and also from the standpoint of overduty on existing circuit breaker installations.

Lightning Protective Devices Subcommittee. The "Application Guide for Lightning Protection of Substations," will deal with the selection and application of lightning protective devices for the protection of equipment in substations. Factors taken into consideration will include system operating conditions, distance of protective devices from apparatus protected, grounding conditions, and other related factors. Included in the guide will be problems peculiar to some unit-type stations where, because of cable connections, the location of lightning

protection equipment may be a considerable distance from protected equipment. It is expected that this guide will be completed and presented at the Fall General Meeting.

The subcommittee is preparing a revision and combination of AIEE Standards 24, Protective Tubes; 28, Lightning Arresters for A-C Power Circuits; and 47, Expulsion-Type Distribution Lightning Arresters. Agreement has been reached on all of this proposed Standard, except for the dielectric tests on the insulation assemblies of the so-called grounded neutral arresters. It is expected that values for these tests will be agreed upon shortly so that the Standard may be reported to the main committee, with the possibility that a covering paper could be presented at the Fall General Meeting.

A report on "Performance Characteristics of Lightning Protective Devices," of present-day station-type 20- to 73-kv line-type 3- to 15-kv distribution arresters, line-type expulsion arresters (expulsion tubes), and rod gap characteristics, is in preparation. It will combine in one place the important characteristics of the various types of protective devices available. It is expected to be presented at the Fall General Meeting. This activity is followed closely by the AIEE delegation to the Triple Joint AIEE-EEI-NEMA Committee on Insulation Co-ordination.

A symposium on "Recovery Voltage Characteristics of Distribution Systems," was presented at the 1949 Winter General Meeting, covering both field and laboratory test data on the recovery voltage characteristics of distribution systems. These data now are being correlated with the probable range of pertinent parameters of existing systems, and the next step will be to make use of them in setting up duty cycle test specifications for incorporation in a future revision on that part of the combined arrester Standard dealing with expulsion arresters. These data also should prove useful to other groups concerned with Standards on distribution circuit fuses, circuit reclosures, and so on.

This activity has been carried on by a joint working group sponsored by both the Lightning Protective Devices Subcommittee and by the General Systems Subcommittee of the Committee on Transmission and Distribution.

Co-ordination of Insulation Subcommittee. This subcommittee was established to handle problems within the Committee on Protective Devices dealing with co-ordination of insulation. Its function has been to keep the members of the main committee informed concerning the activities of other committees that are doing work dealing with insulation co-ordination.

COMMITTEE ON RELAYS

The technical activities of the committee have required three meetings, and one to three meetings of each of its ten project committees. The 11 formal and six conference papers presented have included one final committee report and one preliminary report. A conference session was sponsored at the Winter General Meeting. Revised Standards for power relays have been prepared and are being submitted to the Standards Committee. The principal technical activities were carried on through project committees, which are appointed to fulfill specific assignments.

Generator Protection. Investigation of loss of excitation of generators and associated protection methods has provided further data for a committee report now being formulated to summarize the protection of a-c generators. Two conference papers on this phase of the problem will be presented at the Summer General Meeting. The influence of partial winding faults to ground on the capability of relaying systems to provide positive protection is receiving particular attention, especially in view of neutral grounding schemes which limit fault current to small values with faults at the generator terminals. Papers are being encouraged to provide better methods for calculating the currents associated with partial winding faults with various grounding methods.

Bibliography of Relay Literature. An interim report covering references to technical articles on relaying in the American and foreign press which have been published since the last formal report of this project committee has been distributed to the committee and other interested individuals. It is planned that another formal report covering three years will be available in 1950.

Co-ordination of Construction and Protection of Distribution Circuits (Joint Group). This joint working group of the AIEE Committee on Relays, the AIEE Distribution Subcommittee, and the EEI is continuing with the study of correlation of distribution circuit construction and protection practices. Three meetings of the group were held. As a result of these activities, some 30 electrical utilities are participating in a study which will provide performance data on representative distribution circuits. Special records are being kept on the number of transient and sustained faults, the extent and duration of interruptions to customers, and the correlation of this information with construction and protection details such as, relay settings, protection, conductor size, material, covering and spacing, span length, surge protection.

Standards for Power Relays. The project committee has completed a final draft of a proposed revision of ASA Standard C-42, "American Standard for Relays Associated with Electric Power Apparatus." This draft has been approved by the project committee and the Committee on Relays, and is being transmitted to the Standards Committee. The proposed new Standard would modernize previous definitions, amplify the bases of rating, including current, voltage, temperature, range of operating voltage, and dielectric tests. For the purpose of future revisions, information is being formulated on additional performance data such as fidelity of characteristics as influenced by variations in temperature, wave form, and the like.

Insulation Levels for Relays and Control Circuits. A value of 1,500 volts alternating current has been adopted as being an adequate test voltage for the current, potential, and trip circuits of relays and associated circuits. An investigation of the standard recommended contact spacings for various types of high-speed relays showed that all of these are adequate to withstand a test of at least 1,500 volts alternating current across contacts (provided any arc suppressive devices are disconnected).

An individual paper, "Voltage Surges in Relay Control Circuits," was presented at the Midwest General Meeting, outlining the origin of transient voltages in relay circuits and reviewing methods for reducing these voltages. The Committee on Switchgear has been asked to consider a provision in future revisions of circuit breaker Standards which would require limiting the transient voltage produced by inductive "kicks" of operating solenoids to 1,500 volts crest (or lower if feasible).

Sensitive Ground Protection. A preliminary report of this project committee was presented at the Winter General Meeting. Based on additional discussions, the project committee is preparing a final report which will summarize available methods for sensitive ground protection of 3-wire systems and outline the limitations of present available methods for the protection of systems with multigrounded neutrals.

Transmission Line Protection. Back-up protection and its influence on transmission-line relaying has been given special emphasis. Three conference papers on back-up protection were presented at a conference session during the Winter General Meeting. Discussion developed that recent trends toward heavier loading of transmission lines have minimized the available inherent "back-up protection" formerly obtained as a by-product of sensitive relay settings. Several schemes for providing local back-up protection have been developed, but all appear to have undesirable limitations. A survey is underway to determine present and preferred practices in back-up protection.

Electronic Relay Applications. This project committee is seeking to develop additional favorable applications of electronic devices to protective relaying. Two individual papers were presented, one at the Midwest General Meeting, describing an actual installation of all-electronic distance relays, and the other at the Winter General Meeting covering laboratory models of electronic distance and other relays with test information. The project committee also is studying the application of microwave channels to protective relaying.

Relaying of Interconnections Between Industrial and Utility Generating Systems. This project committee is continuing its investigation of the special relaying problems encountered in the parallel operation of industrial generating systems with those of interconnected transmission systems.

Protection of Stations Without High-Voltage Switching. In line with modern trends toward simplified switching schemes, this project committee has completed a survey of present and preferred practices in the protection of stations without high-voltage switching. Increasing costs of equipment and improved reliability of power transformers have emphasized the desirability of dispensing with high-voltage circuit breakers wherever justifiable. Protection schemes include single- and 3-pole automatic grounding switches actuated by local differential relays and also various schemes of remote tripping of line circuit breakers. The work of the group was completed with

the presentation of a project committee report at the Winter General Meeting. However, it is expected that certain phases of the problem may justify additional investigation, and consideration is being given to this as one of the future projects of the Committee on Relays.

Joint and Associated Projects. Through representation, the committee has participated in the activities of the Instrument Transformer Subcommittee of the Committee on Transformers with special attention to the relaying performance of current transformers and the transient performance of capacitance potential devices. Close coordination has been maintained with activities of the Committee on Carrier Current and a special subcommittee to study circuit breaker duty on out-of-phase switching.

COMMITTEE ON ROTATING MACHINERY

A total of 48 papers, sponsored by this committee, were presented at the AIEE meetings during the past fiscal year. Of these, 29 were presented at the Winter General Meeting. The main committee meeting was held during the Winter General Meeting. Subcommittee activities reported at this meeting are briefed in the following:

Insulation Resistance Subcommittee. Report 43A "Recommended Practice for Insulation Testing of Rotating Machinery," was presented to the committee. Final agreement on this report is expected shortly, after which it will be published as an AIEE Standard.

D-C Machine Subcommittee. Results of the 3-year motor test program on motors from 1/2 to 50 horsepower and 1,750 rpm, conducted by five co-operating electrical manufacturers, were reported at the technical sessions of the Winter General Meeting. The results indicate that a revision of Standards is necessary relative to the measurement of temperature rise on d-c machines; results on large machines differ from those obtained on small machines and additional data must be obtained on large units. Further work of the committee includes obtaining further data on temperature rises on large d-c machinery, revision of Standards on temperature rise measurements on d-c machines, the investigation of a standard method for determining short-circuit currents on d-c machines.

Fractional-Horsepower Subcommittee. Current activities of the committee include the formulation of a test code for fractional-horsepower motors. Future plans of the committee include the formation of an application guide for fractional-horsepower motors. It was agreed in committee that fractional-horsepower d-c machines, as well as a-c machines, will be covered by this committee.

Induction Machine Subcommittee. A test code for induction machines is in preparation and it is hoped that this will be completed in time for consideration at the Summer General Meeting. A session on the application of induction motors is contemplated for a future meeting.

Synchronous Machine Subcommittee. Minor revisions in the test code are contemplated.

Test Code Subcommittee. A co-ordinating subcommittee of this committee has been formed to integrate and co-ordinate test code activities.

During the discussion of these reports and other business by the main committee the following recommendations were made:

1. The Committee on Instruments and Measurements be asked to establish Master Test Code for Power Measurements.

2. The publication policy of the Institute be reviewed to permit the publication of a greater number of papers resulting from the increasing activities of the technical committees.

A report on the compilation of a bibliography on rotating machinery indicated this project is nearly complete with a total of 394 volumes having been reviewed, from which 1,408 articles have been catalogued under 12 major and 47 minor classifications. It is expected that this bibliography will be published when completed.

COMMITTEE ON SUBSTATIONS

Work in Progress. This committee, formerly the Committee on Automatic Stations, recently completed organization of its subcommittees and working groups to cover the greatly expanded scope of the committee. The main committee has assigned the projects mentioned in the following for study and possible action by the subcommittees concerned. So far, little has been accomplished on any of these projects, because they were only recently assigned.

The Automatic and Supervisory Control Subcommittee has been assigned projects relating to investigating the reliability of supervisory and automatic control for substations, and also revision of American Standard C37.2-1945 covering such equipment.

The Transmission Substations Subcommittee and the Distribution and Conversion Substations Subcommittee have in hand projects dealing with the relative merits and standardization possibilities of the 1-line diagram connections and structural design of the substations falling within their jurisdiction, also the problem of safety considerations in substation design, station lighting practices, and the problem of station auxiliary power supply for substations.

The Distribution and Conversion Substations Subcommittee also has been assigned projects covering the relative merits of circuit breakers versus reclosing fuses for small distribution substations and the choice of bus regulation versus feeder regulation for distribution substations.

The Working Group on Device Function Numbers has prepared and recently circulated a questionnaire regarding the adequacy of the present standard device numbers as established in American Standard C37.2-1945. The work of that group will be very valuable in considering the next revision of that American Standard.

The Working Group on Rectifier Switchgear, which is responsible for treatment of all matters pertaining to the design, construction, and application of switching devices, instrumentation, and protective and functioning relays for electronic power converters, has prepared a conference paper on Electronic Power Rectifier Protection that was presented at the Winter General Meeting. This paper will be followed by a formal paper of similar scope intended for presentation at the Summer General Meeting.

The Working Group on Substation Grounding Practice is responsible for investigation and study of substation grounding system design and testing practices, including consideration of the relative merits of galvanized iron versus copper electrodes. This group includes representation from two of the subcommittees of the Committee on Protective Devices.

AIEE Papers. This committee sponsored papers at a joint technical session at the Midwest General Meeting, with the Committee on Transmission and Distribution. This committee expects to sponsor a technical session at the Summer General Meeting, and also one at the Fall General Meeting.

Committee Meetings. The main committee met in Milwaukee on October 20, and in New York on January 31. A meeting also is scheduled for June 20 at Swampscott.

COMMITTEE ON SWITCHGEAR

The Committee on Switchgear sponsored technical sessions at the Midwest and Winter General Meetings. It will sponsor a similar session in June.

The committee held one meeting during the Winter General Meeting.

Proposed Standards for Automatic Circuit Reclosers for A-C Distribution Systems have been submitted to the Standards Committee with the recommendation that they be approved for a 1-year trial.

A Guide for Application of Low-Voltage Circuit Breakers has been prepared and submitted to the committee for letter-ballot. The balloting is nearly completed and indicates the acceptance by a large majority of the committee. This guide will be discussed at the Summer General Meeting.

The Subcommittee on Circuit Breakers is working on a proposed revision of ASA Standards for Power Circuit Breakers.

Last year the committee approved for submission to the Standards Committee a proposed Standard on Air Interrupter Switches and a proposed revision of Standard 22 covering "Air Switches and Bus Supports." At the committee meeting in January, it was pointed out that these two Standards had much in common and were very closely related. It was agreed that they would be combined into one, to be submitted to the Standards Committee. This combination has been made, and the combined Standard is being submitted to the Standards Committee for action.

Proposed revision of the Standard on Switchgear Assemblies, 27, was approved by the committee for submission to the Standards Committee, and has been so submitted.

COMMITTEE ON SYSTEM ENGINEERING

This report covers the work of the second year of the committee. The general program of subcommittees was continued. However, there was considerable enlarging of the committee in that 14 new members were added at the end of the first year to give broader diversification, geographically, and to strengthen the important System Planning Subcommittee.

The committee sponsored three sessions during the year—two at the Midwest General Meeting, and one at the Winter General Meeting. A total of 13 formal papers and 8 conference papers have been presented by the committee. There were two committee meetings during the year. At these meetings, plans of the committee for future meetings were outlined. The report of the program of the Power Group Co-ordinating Committee has been presented, and the reaction of the committee to the publication policies of the Institute have been discussed. In general, it has been the policy of this committee to present a full and adequate review of one phase of system engineering at any session it sponsors.

It prepared two papers for the Summer General Meeting, one covering the broad subject of the principles in the design of a utility system from the generating station through to the ultimate distribution system, and the second covering a basic change in the system frequency of one system and the problems associated therewith. Both papers were well received. The committee also prepared a paper which was presented at the Pacific General Meeting, dealing with the economics of transmission design in overall system planning.

System Planning Subcommittee. This subcommittee sponsored two papers at the Midwest General Meeting, one on the development and growth of a large all-hydro system and the second on a similar development of a metropolitan steam system. These papers emphasized the fundamental factors influencing the development of these systems and demonstrated the influence of these factors in future planning. Similar papers are scheduled for the Summer General Meeting on another type of metropolitan system using extensive subtransmission voltages, and a smaller system where the genera-

tion is located away from the load centers. There was also a paper presented at the Winter General Meeting on the use of the calculating board in system planning.

System Controls Subcommittee. This subcommittee sponsored a group of conference papers at the Midwest General Meeting, dealing with the subject of turbine and boiler design to meet fluctuating loads. These conference papers provoked so much discussion, not only at the meeting, but also in the technical press afterwards, that they were made the basis for three formal papers and two conference papers at the Winter General Meeting. This subcommittee also sponsored two papers on load control apparatus at the Midwest General Meeting, and has prepared a committee report on the status of automatic load control equipment.

System Operations Subcommittee. This subcommittee sponsored a companion group of three papers at the Midwest General Meeting on the subject, "Emergency Control of System Loads." The subcommittee also has undertaken a study of the problem of load pickup on radial and network feeders following prolonged shutdowns, made at the request of the Committee on Substations. This study is planned for presentation at the 1949 Fall General Meeting.

Interconnection Contracts Subcommittee. This subcommittee has prepared a committee report on various aspects of interconnection operations as influenced by the types of contracts. This report is being circulated only within the committee for future study.

Joint Subcommittees. Representatives also have served on two joint subcommittees, one on probability study of equipment outage, and the other on out-of-phase high-voltage switching. The Probability Studies Subcommittee presented a very complete report at the Winter General Meeting on outage records of steam and hydro-generators and boilers. It is continuing its study of variations in load and load estimating on a probability analysis basis.

COMMITTEE ON TRANSFORMERS

The committee held three meetings, with an average attendance of 21 members. The activities of this committee have been quite varied, and, at the present time, 14 main subjects are under consideration.

Co-ordinated Study of Life of Transformer Insulation Working Group. A program was drawn up for a set of pilot tests on selected class *B* and class *H* materials to be carried out by the four participating laboratories: Allis-Chalmers, Dow-Corning, General Electric, and Westinghouse. The pilot tests are intended: to permit a choice between the test methods proposed by General Electric and by Westinghouse; to train laboratory personnel in the techniques of making the tests. Apparatus and materials now are being accumulated and the pilot tests will be under way shortly.

Temperature Gradients and Hot-Spot Temperatures for Dry-Type Transformers Working Group. The work of this committee was conducted principally by correspondence without formal meetings being held. A tentative value of 110 degrees centigrade was accepted by the Committee on Transformers as the tentative limiting hot-spot temperature rise, after which this working group was dismissed.

Joint Subcommittee on Instrument Transformers. Inasmuch as the interest in instrument transformers is rather broad, an effort has been made to obtain broad coverage by obtaining representatives from other interested technical committees as well as from the Committee on Transformers.

Meetings have been held, and considerable progress has been made. Inasmuch as the subcommittee is rather large, all the work has been carried on in working groups. The following working groups have been established: Relaying Performance of Current Transformers, Test Code, Rating Factors, Grounding Instrument Transformer Secondaries, Definitions, Revision of Test Code for Metering, Separate Publication of Instrument Transformer Standards, Transient Characteristics of Potential Devices.

Subcommittee on Papers. There are nine papers available for the Summer General Meeting. The Committee on Transformers has been assigned two sessions at this meeting.

Operating Guides for Regulators Working Group. The draft of the proposed guide for the loading of oil-immersed step-voltage and induction-voltage regulators was revised several times by correspondence. Each revision was acceptable in all respects except on several fundamental points. These points were agreed upon at a meeting of the working group held on January 31, 1949.

The guide "Proposed American Standard Guide for Loading of Oil-Immersed Step-Voltage and Induction-Voltage Regulators" has been completed by the working group. A letter-ballot is being sent to each member of the Committee on Transformers for approval.

Short-Circuit Thermal Ratings of Oil-Immersed Step-Voltage and Induction-Voltage Regulators Working Groups. The work of this group is to amplify section 15.050 in ASA C57.15 to cover regulators which supply feeders having automatic reclosing circuit breakers; also to check if the regulators will withstand 25 times normal current both thermally and mechanically for the times given in the standard. Since this question was primarily one of determining from the manufacturers the short-circuit thermal and mechanical rating of regulators, the manufacturers of this equipment were consulted. In view of all of the variables involved, the following statement was generally agreed upon:

> When used on circuits with breakers having reclosing cycles, the accumulated time a regulator is subjected to short-circuit current shall not exceed that given in the above table.

This statement was to be added to ASA C57.15 immediately after the table in section 15.050. The Standard now states that regulators must withstand 25 times rated current for four per cent impedance for two seconds. All manufacturers agree that their regulators will meet this requirement.

A letter-ballot was sent to each member of the Committee on Transformers asking for approval of the statement, as a result, the original statement was changed as follows, the words in italics being added:

> When used on circuits with breaker *or other devices, such as fuses,* having reclosing cycles, the accumulated time a regulator is subjected to short-circuit current, *during one reclosing cycle,* shall not exceed that given in the above table.

This question was discussed by the Committee on Transformers. After many comments and suggestions, the problem was referred back to the working group for further consideration.

The suggestion was made that the interpretation of section 15.050 may belong in the Guide for Loading of Regulators. This will be considered, and a recommendation will be made to the Committee on Transformers by the working group at a later date. It was suggested also that similar changes should be made in the guide for loading transformers on the same point.

Subcommittee on Magnetization Characteristics of Transformers. The work of this subcommittee has been divided into three natural divisions:

1. Magnetization characteristics of transformers.
2. Effect of magnetization current on operation of air break switches.
3. Effect of magnetization current on relay problems.

Meetings have been held, and reasonable progress is being made.

Short-Circuit Requirements of Transformers Working Group. At a meeting of the working group, a proposal was drafted for revising sections of ASA C 57–12. In September, the proposal was submitted by letter-ballot to the members of the main committee. After minor revisions, it was approved and adopted by the committee.

Guides for Operation and Maintenance of Dry-Type Transformers With Class B Insulation Working Group. One meeting was held to review data assembled by means of a questionnaire to the working group members and to determine what material should be included in the guides. As a result of this meeting, a draft of a proposed guide was prepared and submitted to the members of the committee for review. Comments have been received on this draft, and a second meeting is being arranged, at which time it is hoped that a revised guide can be prepared for submission to the main committee.

Co-ordination of Insulation Working Group. This is essentially a 1-man committee, whose assignment is liaison between the committee and the AIEE group of the Joint AIEE-EEI-NEMA Committee on Co-ordination of Insulation. Two meetings of the AIEE group have been held and considerable progress has been made.

Electronic Power Converters Working Group. One man was appointed to act as the liaison representative between the Committee on Transformers and the committee on Electronic Power Converters to take care of such subjects as required co-ordination between the two groups.

Subcommittee on Method of Making Transformer Heat Runs. The work of this subcommittee is essentially a continuation of that carried on previously, and has to do primarily with the change in the ASA C 57 Transformer Standard necessary to indicate that the short-circuit method is the standard method and will be used unless otherwise specified and agreed upon. Because of a misunderstanding, serious opposition to the proposed change has arisen in one of the

EEI committees. The immediate task of the working group is to rewrite the proposal so that a misunderstanding will be impossible, and to secure sufficient data to prove that the short-circuit method is reliable and gives correct results within the same degree of accuracy as the back-to-back method.

Revision of Dielectric Tests Working Group. The working group was set up to consider changes in the insulation tests, both as to the magnitude and the technique of testing. Several changes in test procedure have been proposed. One in particular was due to an editorial error, but still remains to be corrected. Another involved changes in testing technique, particularly the use of current neutral measurements during impulse tests. A meeting was held, and tentative plans for changes were made. In order that the group should have broad coverage in the industry, it included several manufacturers' representatives and operators' representatives. Proposals were made, but several differences of opinion were expressed which were of so serious a nature that further work will be required.

COMMITTEE ON TRANSMISSION AND DISTRIBUTION

The past year was marked by continued intensive activity within the subcommittees. The product of this work will come to fruition shortly in the form of five subcommittee reports. In addition to the subcommittee meetings, there were two meetings of the general committee—the first in Milwaukee on October 20, and the second in New York on January 31. A third meeting is planned for Chicago on May 4.

Technical Meetings. Two technical sessions were sponsored by the Committee on Transmission and Distribution at the Summer General Meeting, and two at the Pacific General Meeting. At the Midwest General Meeting, one separately-sponsored session, and one jointly-sponsored session with the Committee on Substations were held. Two solely-sponsored sessions and one jointly-sponsored session with the Committee on Protective Devices were held at the Winter General Meeting. For the Summer General Meeting, one separately-sponsored session and one jointly-sponsored session with the Committee on System Engineering are scheduled.

Capacitor Subcommittee. A revision of AIEE Standard 18 on capacitors is nearing completion by the Capacitor Subcommittee. This Standard has been circulated through the main committee, and requires only slight modifications before submission to the Standards Committee for final approval. A joint report with a corresponding working group of the EEI on the performance of shunt capacitors is likewise nearing completion, and should be available for presentation at the Fall General Meeting. The Capacitor Subcommittee also will have available for presentation at that meeting a report on the maintenance of shunt capacitors.

Distribution Subcommittee. A report of this subcommittee entitled "Preliminary Report on Electric Power Distribution System Practices and Trends in the United States," was presented at the Summer General Meeting. This since has been made a final report and published in *Electrical Engineering*. A Symposium on Primary Network Systems, at which four papers will be presented, is being sponsored by the Distribution Subcommittee for the Summer General Meeting. Consideration also is being given by the subcommittee to an economic study of different values of primary voltages. The subcommittee also is engaged jointly with other groups of the AIEE and EEI in a study of the construction and protection of distribution circuits.

General Systems Subcommittee. A report by this subcommittee on "Power System Overvoltages Produced by Faults and Switching Operations," was presented at the Summer General Meeting. A co-operative survey with a corresponding group of EEI is being made on the causes of outages and operating experience on transmission lines of 100 kv and over. A session at the Winter General Meeting was sponsored in co-operation with the Committee on Protective Devices on "Recovery Rates of Voltage on Distribution Systems."

Lightning and Insulator Subcommittee. One of the active projects of this subcommittee is the preparation of a bibliography of material relating to lightning. This is a compromise with the original plan, which contemplated the correlation and publication of papers relating to the subject similar to the previous Lightning Reference Book prepared by the same subcommittee. This plan was abandoned because of cost. The subcommittee is concerning itself also with a study of recommendations for lightning-proof transmission lines. A symposium of five papers on the subject of insulator contamination and corrective measures was sponsored by this subcommittee and presented at the Midwest General Meeting.

Towers, Poles, and Conductors Subcommittee. A report by this subcommittee on the types of conductors available for use on high-voltage transmission lines was presented at the Summer General Meeting. A report on transposition is under preparation, and should be available for presentation at the Fall General Meeting.

Other Activities. The Committee on Transmission and Distribution is jointly active with other committees in two projects, the first being the investigation of high-voltage switching when out-of-phase voltage exists at the time of arc interruption, and the second is the calculation of short-circuit currents on low-voltage systems.

Co-ordination With Edison Electric Institute. Close co-operation between the Committees on Transmission and Distribution of the EEI and the AIEE has continued during the past year. As mentioned previously, the Capacitor Subcommittee, the Distribution Subcommittee, and the General Systems Subcommittee have active projects that they are carrying on with groups of the Transmission and Distribution Committee of EEI.

Industry Group

COMMITTEE ON CHEMICAL, ELECTROCHEMICAL, AND ELECTROTHERMAL APPLICATIONS

The committee held one meeting, in New York during the Winter General Meeting. The accomplishments of the past year were reviewed and plans discussed for the coming year. The scope of each subcommittee was reviewed and specific projects outlined for 1949.

This technical committee is now composed of the following subcommittees: Arc Furnaces and Electrothermal Processes; Electrolytic Processes; Cathodic Protection; Metallic Rectifiers; Petroleum Refining and Production; Batteries, Battery Forming, and Charging; Chemical Industries. The subcommittees engaged in the following activities during the year.

Arc Furnaces and Electrothermal Processes. This subcommittee is studying to establish good engineering practices in these fields. Problems relating to design and installation are of particular interest and a number of papers covering selected phases of the subject will be sponsored in 1949.

Electrolytic Processes. This subcommittee held a meeting during the Winter General Meeting to discuss future plans. It is continuing its work on matters relative to theory, technique, plant efficiency, application of power conversion equipment, and operating hazards. It is engaged in the preparation of a subcommittee report on the influence of electrolytic cell line characteristics on the selection of electric power and conversion equipment.

Cathodic Protection. This subcommittee now is working on a report relative to design and operation of apparatus and systems to minimize corrosion. A number of papers on corrosion prevention will be sponsored this year.

Metallic Rectifiers. This subcommittee is continuing its standardization work on metallic rectifiers. Two technical sessions are planned for the Summer General Meeting on theory, design, and application of metallic rectifiers.

Petroleum, Refining and Production. This subcommittee sponsored two papers at the Summer General Meeting on the electrification of pipe lines and oil well pumping by electric power. It also sponsored a conference at the Winter General Meeting on wiring and distribution systems for petroleum refineries.

Batteries, Battery Forming, and Charging. This subcommittee is actively studying battery ratings and battery applications to clarify inconsistencies in present Standards, and it also is sponsoring a conference at the Summer General Meeting on batteries and battery charging.

Chemical Industries. This subcommittee sponsored a conference at the Winter General Meeting on wiring and distribution systems for chemical plants, and jointly sponsored, with the Committee on Transmission and Distribution, a conference on heat balance in chemical plants. The subcommittee is actively studying the application of electric equipment to the chemical industry, particularly switchgear and control devices, to establish good engineering practices to meet the exacting requirements of this industry.

COMMITTEE ON ELECTRIC HEATING

The principal activity of the committee during the past year has been the sponsorship of two conference sessions on electric

heating at the Midwest General Meeting, which were well attended. The papers covered resistance heating, induction and dielectric heating, and radiant heating. The committee met in New York on February 3, 1949. At this meeting, each of the subcommittee chairmen reported on the activity of his subcommittee during the past year. Since the major work of the committee is carried on through the subcommittees, the remainder of this report consists of abstracted portions from the subcommittee reports.

The Subcommittee on Electronic Heating has proceeded with an agenda agreed upon by the Joint AIEE, IRE, NEMA Co-ordination Committee on Induction and Dielectric Heating. Various working groups within the subcommittee have been given specific assignments, some of which already have been completed. A Standard has been formulated on good engineering practice in the case of radio interference, which covers the proper methods of shielding, grounding, and installation of this equipment. The report has been accepted by the subcommittee and has been tentatively approved by the IRE. The report will be presented at the 1949 Summer General Meeting.

A data sheet for use by the FCC in reporting cases of radio interference has been formulated. This form has been accepted by the FCC, and is now in use by all their field engineers for cases of radio interference from industrial equipment. A set of standard definitions for induction and dielectric heating is being prepared. It is planned eventually to incorporate all such information in a formal Standard.

The Subcommittee on Radiation Measurements Above 200 Megacycles met five times during the year, the work following closely the pattern set during the preceding year. It is still thought that the best method for measuring radiation field strengths in the range of 200 megacycles and above is by the substitution method, using a standard signal generator, a suitable calibrated receiver, and a pickup device having known characteristics. Through a study of the literature and the building and testing of dipoles, dipoles with corner reflectors, and horns, the subcommittee has become convinced that it will be possible to give constructional details for various pickup devices which, when constructed according to specification, will permit the measurement of field strengths in the range from 200 megacycles to 7,350 megacycles with an accuracy of plus or minus approximately 20 per cent. This assumes the use of proper equipment, smooth lines, and proper technique, all of which must be described in a final specification of recommended procedure. Preparing such a Standard will be the major work of the coming year.

The Subcommittee on Resistance Heating and Electric Furnaces met twice during the year, and played a prominent part in the conference on electric heating held in Milwaukee in October 1948. Several project groups have been formed within the subcommittee to collect and prepare technical data with the hope it can be made available ultimately in some well edited form for the use of engineers. Close co-ordination is maintained with the Subcommittee on Radiant Heating because of the overlapping nature of resistance and radiant heating.

The Radiant Heating Subcommittee has 22 members, and is organized with 11 project groups working on specific problems. The subcommittee met four times in places widely separated geographically. Nine inspection trips were held in conjunction with these meetings, and several pages of publicity including photographs on these activities have been obtained in such publications as *Electrical Engineering*, *Electrical World*, *Industrial Heating*, *Industrial Finishing*, *American Paint Journal*, *Products Finishing*.

The subcommittee currently is assisting the National Fire Protection Association in connection with a code revision on industrial ovens and furnaces. It is further preparing numerous recommendations although to date only one official action has been taken, namely that the AIEE adopt and recommend through C-42 that infrared be spelled without a hyphen. The subcommittee activities now fully embrace industrial radiation heating with both lamp and glassless high-temperature resistance heaters.

COMMITTEE ON ELECTRIC WELDING

Conference on Electric Welding. The committee in co-operation with the Michigan Section sponsored a 3-day Conference on Electric Welding in Detroit. The purpose of this conference was to provide a forum on welding in Detroit, which is the center of this activity. One day was devoted to arc welding, and two days to resistance welding. The results of this conference were very gratifying because an attendance of over 400 was obtained. This is to be compared with a usual attendance, at similar sessions held during general meetings, of 35 to 100, depending on subject and location. The conference was so well received that plans are being made to repeat it in 1950.

Bibliography. The committee published a bibliography of resistance welding, prepared by Mr. Zucker.

Subcommittee on Power Supplies for Resistance Welding. Additional papers have been prepared and presented, also data gathered for a revision of the present report on "Power Supplies for Resistance Welding." Work of this subcommittee is about 40 per cent complete. This work will go on until possibly 1950 before being ready to publish.

COMMITTEE ON GENERAL INDUSTRY APPLICATIONS

Principles of Work. The committee has endeavored to follow the principles which were laid down when it was formed in the summer of 1947: (*a*) To study, discuss, and clarify electrical engineering problems in the several industries assigned to the committee, and (*b*) to attract to AIEE and to this work the electrical engineers interested in the foregoing industries.

In order to carry out this work effectively, it was necessary to subdivide it among several subcommittees, each to cover an industry or a group of related industries. The subcommittees are the Subcommittee on Machine Tools, Subcommittee on Rubber and Plastics Industries, Subcommittee on Textile Industry, Subcommittee on Pulp and Paper Industry, Subcommittee on Materials Handling. This list does not cover, by any means, all industries which come within the scope of the committee. One of the problems discussed at the February 3 meeting was: "Shall we organize additional subcommittees to cover additional industries?"

Subcommittee on Machine Tools. This subcommittee organized a very successful all-day session at the Midwest General Meeting. The topic selected was "Automatic Contour Follower Control for Machine Tools." Nine papers were presented. The meeting was very well attended. Discussions were interesting and lively. It is hoped these papers and their discussions can be published in one pamphlet, which will be an authoritative reference book on this subject.

This subcommittee did not plan on holding any additional machine tool sessions in 1948–49, but is working on the program for a session at the Fall General Meeting. The plans call for a 2-day session, with trips to several machine tool manufacturing plants in the area.

Subcommittee on Rubber and Plastics Industries. This group has arranged to hold annual meetings. Considering the geographical location of the rubber industry, Akron, Ohio, has been selected as the preferred place for the meetings, which will be arranged jointly with the Akron Section. The date for the 1948–49 meeting was set for April 26, 1949. This was an all-day affair. The program included discussion of: banbury drives, mill drives, calender drives, tuber drives, electrical standards for industrial equipments, and preventive maintenance. The papers and discussions will be published in pamphlet form, as has been done in connection with the April 20, 1948, meeting in Akron.

Subcommittee on Textile Industry. A session was held during the Winter General Meeting. This was devoted to the synthetic fibres industry, and consisted of four papers, one a presentation by title only. Two conferences are scheduled for the spring, one in Boston on May 3, and one in Atlanta on May 26 and 27.

Subcommittee on Pulp and Paper Industry. This group held a technical session at the Midwest General Meeting. The theme of the session was the "Speed Regulators for Sectional Paper Machines." Three papers were presented. The meeting was well attended (about 125) with many paper mill engineers present. This subcommittee is planning to hold the next session at the Summer General Meeting, the theme being "Electric Drives for Supercalenders and Winders." Two committee reports will be presented.

Subcommittee on Materials Handling. One technical session was held at the Midwest General Meeting. Two papers were presented. The topics were discussed at great length by many engineers attending the meeting. The subcommittee is planning the organization of a special one-day conference on May 13, 1949, in Cleveland, jointly with the Cleveland Section. The theme of this meeting will be heavy materials handling equipment such as needed for ore bridges and unloaders.

Reviewing the activities for the last year and a half, it appears that the committee met with some degree of success in its main task: "To bring AIEE closer to engineers working on industrial problems." The technical sessions organized by the subcommittees represent the sole ground on which these

engineers can meet others in the same fields and discuss the problems which loom the largest in their professional lives. It is noted that there are no engineering organizations in existence (except these subcommittees), which discuss electrical engineering problems in such industries as machine tools, rubber, textile, paper, and materials handling. Hence, this work begins to fill a definite need. Efforts will be made to make it more effective, and to lay plans for the future.

Note: L. A. Umansky, Chairman of the Committee on General Industry Applications, his committee, and subcommittees merit special mention due to the number of successful technical committee conferences which they have conducted during the year and for the number planned for the future.

COMMITTEE ON INDUSTRIAL CONTROL

The committee has continued to take an active part in the work of the Industry Coordinating Committee, and every effort has been made to interest industrial engineers by preparation and presentation of papers relating to control problems in industry.

The Subcommittee on Standards has completed its work on the revision of Standard 15—Industrial Control Apparatus. The new Standard has been forwarded to the American Standards Association through the Standards Committee.

The Subcommittee on Electronic Control has been active in the formation of five working groups. These groups are concerned with: electronic control of d-c motors, photoelectric control systems, electronic relaying devices, electronic regulators and regulating systems, and electronic control of a-c power. Considerable work has been done by these groups on definitions in close co-operation with corresponding groups of the American Standards Association.

The Subcommittee on Electronic Control in co-operation with the Committee on Electronics, sponsored a 2-day Conference on the Industrial Applications of Electron Tubes, in Buffalo, in April.

The Subcommittee on Test Codes is proceeding with a code on interrupting ability of contactors and endurance tests on a-c contactors. Numerous other subjects are under consideration by the subcommittee. The bibliography referred to in last year's report has been brought up to date, and final abstracting is now in progress.

The Subcommittee on Servomechanisms, jointly sponsored by this committee and those on Basic Sciences and Instruments and Measurements, conducted a well-attended session at the Winter General Meeting, and joined in a second session with the Committee on Industrial Control. It is hoped that in the near future a close liaison will be established between this joint subcommittee and the Subcommittee on Electronic Control.

During the year, the committee sponsored two sessions at the Midwest General Meeting and two at the Winter General Meeting. The sessions were well attended, and the papers presented were freely discussed by the members.

COMMITTEE ON INDUSTRIAL POWER SYSTEMS

This committee sponsored a session on industrial power distribution systems at the Midwest General Meeting. Three papers were presented at this meeting. Chemical and petroleum industry problems were covered at the Winter General Meeting. Papers on power generation and steam balance were given at this meeting.

The committee has three subcommittees: the Subcommittee on Wiring Design for Commercial Buildings is expected to complete its work and issue its final report at the Summer General Meeting; the Subcommittee on Revision of the Red Book is now actively engaged in revising and bringing up to date the so-called Red Book on Industrial Power Distribution Systems; the Subcommittee on Transformer Ratios was appointed mainly as a group to watch developments in the EEI-NEMA Transformer Voltage Standardization Program.

COMMITTEE ON MINING AND METAL INDUSTRY

The Committee on Mining and Metal Industry was newly formed in 1947, at which time it was called the Committee on Mining, Metal Forming and Rolling. At the present time it has 33 members, and is divided into two subcommittees, one covering the metal industry, and the other covering the mining industry. The members of this committee have been very active and have co-operated to the fullest extent in the committee program.

The first major activity of this committee was the presentation at the 1948 Winter General Meeting of 22 papers in six sessions. Much interest in these sessions was exhibited by men from the steel and mining industries. The committee sponsored a session on steel and a session on mining at the Summer General Meeting. The committee also sponsored two papers for the Pacific General Meeting. At the Midwest General Meeting, the committee presented 11 papers in three sessions, which covered mining, ore beneficiation, and steel mills. Because of the lack of space, the committee was asked not to sponsor sessions for the Winter General Meeting and the Summer General Meeting.

The committee has held several meetings, the last of which was at the Winter General Meeting. A good percentage of the committee attended. Glenn B. Southward, Mechanization Engineer of The American Mining Congress, also attended and gave many helpful suggestions on the work of the committee and on co-operation with The American Mining Congress.

The committee now is making preparations for three sessions at the Fall General Meeting.

Communication and Science Group

COMMITTEE ON BASIC SCIENCES

The Committee on Basic Sciences, as its name implies, deals with the investigation and presentation of subjects of fundamental nature likely to be of present or future interest to electrical engineers. It is the duty and purpose of the committee to sponsor, and present to the members of the Institute the results of activity in newly developing fields not easily assignable—at least in the initial stages of their development—to one of the established technical committees of the Institute. When, in the opinion of the members of the committee, fundamental activity in a field becomes great enough, a subcommittee for the particular field is formed, which concerns itself with this field exclusively. Often the fundamental activity in a new field leads to practical engineering applications not fitting well into an established technical committee, in which case the subcommittee becomes a full-fledged new technical committee of the Institute. For instance, the Committee on Basic Sciences had a Joint Subcommittee on Servomechanisms with the Committee on Industrial Control and the Committee on Instruments and Measurements; this subcommittee now is being considered for elevation to full technical committee status with the suggested name of "Committee on Feedback Control Systems."

The Committee on Basic Sciences sponsored technical sessions at the Midwest General Meeting, and at the Winter General Meeting. At these two meetings, a total of nine papers were presented.

The committee also held two meetings, one at the Midwest General Meeting, and one at the Winter General Meeting, at which it dealt with the question of standardization of voltage notation, the reports and plans of its subcommittees, and the possible formation of new subcommittees.

Activities of the five subcommittees operating through the year are reported in the following:

Energy Sources. The subcommittee sponsored its third conference on energy sources at the Winter General Meeting. Four papers were presented, dealing with the effect of electricity on the human body and on the subject of nerve electricity. The close correlation of this subject with the phenomena of electric fishes was discussed, and a demonstration with electric eels was presented. The attendance at this meeting proved the great interest in this subject. The committee is trying to arrange for publication, in pamphlet form, of most of the 14 papers presented since the formation of the subcommittee in 1946.

Electric Circuit Theory. The Subcommittee on Electric Circuit Theory presented a symposium on circuit analysis at the Midwest General Meeting, consisting of three papers dealing with the history and present state of operational calculus and of the application of matrix algebra, as well as with circuit analysis in servomechanisms. The subcommittee continues to participate in the defining of terms in network theory and electrical measurements, and the chairman of the subcommittee has undertaken to trace out the historical origin of the terms used in circuit theory.

Applied Mathematics. This subcommittee sponsored a Conference on Applied Mathematics jointly with the American Mathematical Society. The conference was held during the Winter General Meeting, four papers having been presented at this time. The subcommittee has further plans for participation in the International Mathematical Convention to be held in Boston, September 1949, and the ASEE meeting in Troy, June 1949. It also is scheduling another conference at the Winter General Meeting of 1950.

Magnetics. This subcommittee formed this year, sponsored a symposium on magnetics at the Winter General Meeting, consisting of morning and afternoon sessions, in the course of which six papers were presented. The attendance at these two sessions indicated that the formation of this subcommittee has filled a definite need. The subcommittee is planning another symposium on the subject for the Winter General Meeting of 1950.

Electrical Properties of Solids. This subcommittee was formed during the past year. The properties of semiconductors only recently have begun to be understood a little more clearly, and the development of the transistor has attracted a great deal of interest. Recognizing this, the subcommittee has prepared a symposium on the electrical properties of semiconductors and transistors to be given at the Summer General Meeting. Owing to the great interest in these devices by other technical societies, activities are under way to establish a joint AIEE-IRE committee on jointly sponsored annual symposia on this subject, so that duplication of effort will be avoided. Initial plans have been made by the subcommittee for a future symposium on "Electrical Properties of Dielectrics."

Electrical Properties of Gases. This subcommittee is still

in the process of formation but can be expected to become active in 1950.

COMMITTEE ON COMMUNICATION

The Committee on Communication has continued its policy of allocating practically full responsibility to the subcommittees and the associated chairmen for the initiation of the technical programs in their particular fields of interest, solicitation and review of timely papers, and conduct of the sponsored sessions. The general steering of these communication activities has been under the guidance and direction of a co-ordinating committee including the three administrative officers and the chairmen of the nine technical subcommittees. Functioning essentially on a group basis for the past two years, the committee has requested Board of Directors' approval of the advancement of the subcommittees to full committee status in an autonomous Communication Group, effective August 1, 1949.

During the past fiscal year, the committee sponsored 11 complete technical sessions, at which 48 papers were presented that specifically covered the fields of telephone switching, wire and radio communication systems, aural and television broadcasting, railroad, and other special communication applications.

The Summer General Meeting was supported by the committee with four papers on telephone, telegraph, and radio subjects. Two papers on the status of radio telephone service in the United States were contributed to a joint electronic and communication session at the Pacific General Meeting.

Participation in the Midwest General Meeting was extended by sponsoring five complete sessions that covered a comprehensive list of subjects including home radio receivers, microgroove recording, television broadcasting and associated coaxial and radio relay facilities, development in semiconductors and the transistor, and telephone and telegraph switching systems. In view of the locale for the meeting a full session was devoted to "Radio on the Great Lakes."

For the Winter General Meeting, the committee sponsored a 5-paper home radio and broadcasting session; radio communication systems session with four papers; 5-paper session relative to wire communication systems; and a fifth session composed of five papers on special communication applications.

Two meetings of the main committee were held for the consideration of general policy matters. The co-ordinating committee met three times during the year in order to formulate the general program of activities and for the discussion and approval of the arrangements worked out by the subcommittees.

The communication program for the Summer General Meeting has been finalized to provide for three sessions, and a total of 12 technical papers, with the principal emphasis being focused on a telephone switching symposium that will deal with the fundamental and functional design of relay switching circuits. Tentative plans are under way for the 1949 Fall General Meeting with a possibility of underwriting five sessions highlighted by a symposium on coaxial systems.

COMMITTEE ON COMPUTING DEVICES

Activities of the Committee on Computing Devices so far have been to sponsor several sessions at AIEE meetings, including a session on analog computers at the last Winter General Meeting, as well as several articles on computing machine developments in *Electrical Engineering*. A session is planned for the Summer General Meeting.

Two major subcommittees have been formed, one on analog computers with Dr. E. L. Harder as Chairman, and one on digital computers with Dr. J. W. Mauchly as Chairman.

Professor G. D. McCann is compiling a bibliography on computing machines, and Dr. W. H. MacWilliams, Jr., is co-ordinating with the IRE and ACM (Association for Computing Machinery) on nomenclature and definitions. Professor S. H. Caldwell maintains contact with the Committee on Instruments and Measurements, while C. Concordia (Chairman) and Dr. J. G. Brainerd (Vice-Chairman) are also members of the Committee on Basic Sciences. Professor W. C. Johnson, Jr., is Secretary.

COMMITTEE ON ELECTRONIC POWER CONVERTERS

The committee activities were concentrated largely on projects initiated during the preceding year. The committee held two meetings—on October 11 in Pittsburgh, and on April 12 in Buffalo. Meetings were held also by several of the subcommittees. A committee report, "Mercury-Arc Power Converters in North America," was presented at the 1948 Summer General Meeting. This is a comprehensive report on the designs and applications of mercury-arc rectifiers.

Protection of Electronic Power Converters. Part 1 of the report on protection, which deals with the calculation of fault currents in rectifier circuits, was completed by the Electronic Converter Circuits Subcommittee, and was presented during the Winter General Meeting, at a technical session on protection sponsored by the committee. Part 2 of the report, which deals with protection systems and devices, is nearing completion and will be presented at the Fall General Meeting. It is being prepared by representatives of the Committees on Substations and Switchgear, in co-operation with the Circuits Subcommittee. The complete report will be published after part 2 has been completed.

Survey of Rectifier Operation. The Electronic Converter Application Subcommittee is making a survey of operating experience and system characteristics in mercury-arc rectifier installations, by means of questionnaires sent to rectifier users. The subcommittee expects to have a preliminary report on the survey ready for presentation at the Fall General Meeting. The complete report probably will be ready for the next Winter General Meeting.

Rectifier Transformer Characteristics. The Rectifier Transformer Subcommittee prepared a report on rectifier transformer characteristics, which was presented at the Winter General Meeting. The report has been submitted to the AIEE for publication.

Bibliography on Electronic Power Converters. The Papers and Speakers Subcommittee has completed a bibliography on electronic power converters, and it has been submitted to the AIEE for publication. The bibliography covers the years from 1903 to the end of 1947. It has 1,550 references to articles in English-language and foreign-language publications.

Inductive Co-ordination on D-C Side of Rectifier Installations. A report on inductive co-ordination aspects relating to the d-c side of rectifier installations is being prepared by a working group under the auspices of the committee. The first draft of the report has been completed. It is expected to have the report completed in time for presentation at the Winter General Meeting.

Conference on Education in Power Electronics. A conference on education in power electronics was held during the Winter General Meeting, under the joint sponsorship of the Committees on Electronic Power Converters, Electronics, and Education. The program included speakers from engineering schools and industry. A report on the conference was published in the April issue of *Electrical Engineering*.

West-Coast Subcommittee. The first organization meeting of this subcommittee was held in Spokane, Wash., on August 26, 1948. The membership of the subcommittee and the scope of its activities were discussed.

COMMITTEE ON ELECTRONICS

One of the very important activities of the committee is that of insuring that early and adequate attention be given by the AIEE to new techniques and engineering practices employing electronic devices. In pursuit of that objective, the committee has added, during the past year, a Subcommittee on Magnetic Amplifiers, and a Subcommittee on Electronic Applications of Semiconductors, and has changed the Subcommittee on Infrared Applications to a Subcommittee on Industrial Spectroscopy, thus enlarging its scope.

The practice of operating with two distinctive types of subcommittees has been continued. One type deals with general functions, such as the processing of Standards, papers solicitations and Section contacts, maintenance of national and informational contacts, education, and liaison with other professional groups. The other type is responsible for attention to specific technical fields. The committee ended the year with seven general-function subcommittees and with 14 subcommittees dealing with specific technical activities.

Plans of operation for the 1948–49 period were formulated at a meeting of subcommittee chairmen in New York, N. Y., in September 1948. A meeting of the entire committee was held in Chicago, in November 1948, in connection with the National Electronics Conference. A meeting was held at the Winter General Meeting.

At the Summer General Meeting, the committee sponsored a technical session dealing with general trends in: electron tube design, mercury-arc converters, and radio-type equipment. Also, the committee assisted in arranging for a discussion of "Electronics in Engineering Education," in a program sponsored by the Committee on Education.

At the Winter General Meeting, the committee sponsored:

1. A technical session dealing with recent developments in electron tubes and circuits.
2. The usual conference session on new electronic devices.
3. A technical session on high-frequency cables.
4. A conference session on education in power electronics.
5. A technical session on electrostatic precipitation.

One of the committee's policies is to encourage the presentation, in sessions sponsored by other committees of the Institute, of papers having an important electronics content. It is interesting to note in this connection that approximately one-half of all of the papers which were presented at the Winter General Meeting referred to some phase of electronics as an essential feature of the treatment.

For the 1949 Summer General Meeting, the committee will sponsor a technical session on infrared applications, and a technical session on magnetic amplifiers; it also will add support to the symposium on semiconductors, sponsored by the Committee on Basic Sciences.

Late in November 1948, a 3-day Conference on Electronic Instrumentation in Nucleonics and Medicine was held in New York, N. Y., sponsored jointly by the Committees on Electronics and Nucleonics of the AIEE, and the Nucleonics Studies Committee of the IRE. This conference was very well attended, and indications are that a similar conference will be held in the late fall of 1949.

In April 1949, a 2-day Conference on Industrial Electron Tubes was held in Buffalo, jointly sponsored by the Subcommittee on Electron Tubes of the Committee on Electronics and the Subcommittee on Electronic Control of the Committee on Industrial Control. This conference consisted of five technical sessions and a dinner meeting. In general, the objective was to permit exchange of information between industrial electronic circuit engineers and industrial electron tube engineers. The conference was very well attended, there was active discussion by those who attended, and it is believed the program was a valuable contribution.

Activities of the subcommittees of the general-function type were as follows:

Electronic Papers Solicitation and Section Contacts. This subcommittee accepts the responsibility for organizing technical sessions at general meetings, for following through to procurement suggestions for technical papers originating within its own members and from members of the technical subcommittees, for encouraging and stimulating papers involving electronics but sponsored by other committees, and for assisting Sections in stimulating electronic contacts.

Electronic Standards. This subcommittee is the channel for processing Standards through to the American Standards Association, and renders active assistance toward familiarizing the committee as a whole with Standards procedures.

Liaison With IRE. This subcommittee has the responsibility of maintaining satisfactory co-ordination with the Institute of Radio Engineers.

Liaison With JETEC. This subcommittee has maintained active co-ordination with JETEC, particularly in regard to matters of policy and areas of standardization activity.

Education in Electronics. This subcommittee has been very active in strengthening contacts as to electronics between industry and universities, and in providing exchange as to points of view among universities in relation to methods of education in electronics. The most significant contribution this year was the technical session on this subject at the Winter General Meeting.

West Coast Subcommittee. This subcommittee has been active in maintaining local contact in the West Coast area, particularly California, between the various electronics activities of importance to the AIEE. Plans are being formulated for a symposium on electronic instrumentation to provide an interchange of ideas between electronic industries in the West Coast area.

Canadian Liaison Subcommittee. This subcommittee is functioning actively in maintaining close contact with electronic developments in Canada, and in addition has maintained a link with electronic developments in Europe.

Activities of subcommittees in technical fields have been as follows:

Electron Tubes. This subcommittee has four working groups in the field of industrial electron tube standards in the following fields: vacuum tubes, cathode-ray tubes, gas-filled thermionic and cold cathode tubes, and mercury-pool cathode tubes. This subcommittee was responsible for the share of the Committee on Electronics in the sponsoring of the Industrial Electron Tube Conference in Buffalo.

X-Ray Tubes and Apparatus. This subcommittee provided two technical papers for a technical session at the Winter General Meeting, has completed its recommendations for changes in regard to X-ray graphical symbols, and has undertaken a revision of the American Standards Association X-ray terms. A study of specifications of characteristics and ratings of tubes used for X-ray equipment is under way.

Electronic Instruments. Activity in the electronic instrument field is handled through the Joint Subcommittee on Electronic Instruments, sponsored co-operatively with the Committee on Instruments and Measurements. This joint subcommittee sponsored two technical sessions at the Winter General Meeting, one on electronic instruments, and one on electronic digital computers. It has actively reviewed the results of the Conference on Instrumentation Tubes held in March 1948 in Philadelphia, and has used the results of that conference for furthering subsequent activities of smaller groups in the same field, and for initiating a Standards program.

Electronic Precipitation. This subcommittee sponsored a technical session at the Winter General Meeting.

High-Frequency Conductors, Cables, and Connectors. This subcommittee was responsible for a technical session at the Winter General Meeting.

Hot-Cathode Electronic Power Converters. This subcommittee has continued to be very active in bringing nearer to completion standard definitions properly correlated with similar standards in mercury-pool rectifiers. Close liaison is being maintained in all respects between this group and the AIEE committee dealing with mercury-pool converters.

Liaison With Nucleonics. This subcommittee has been responsible for maintaining close contact with the activities of the Committee on Nucleonics and other similar groups, and has been instrumental in clarifying judgment as to the proper relationship of the main committee to nuclear studies.

Electronic Aids to Medicine. This subcommittee was the avenue of the sponsorship by the Committee on Electronics of the 1948 Conference on Electronic Instrumentation in Nucleonics and Medicine in New York, N. Y., and is carrying forward plans for a similar conference late next fall. Also, the subcommittee is canvassing the proper setup for adequate liaison with the American Medical Association.

Electronic Aids to Navigation. The responsibility of this subcommittee has been for maintaining close contact with, and making contributions to, the activities of an IRE committee active in this field. Closely associated through overlapping membership is a committee of the Radio Technical Commission for Aeronautics. Liaison is also maintained with the Institute of Aeronautical Sciences, the Joint Technical Advisory Committee, the Air Materiel Command, and the Institute of Navigation. There recently has been achieved by the IRE group agreement on a tentative list of terms and definitions, and other standards procedures are under way.

Electronic Aids to Geophysics. This subcommittee sponsored last fall, jointly with an IRE group, a symposium on electronic circuitry in geophysical work, held in the Texas area where the greatest activity in this field exists. An important objective of this subcommittee's work is to enlarge the area of contact, by means of technical publication and otherwise, between geophysical electronic work and other areas of electrical engineering.

Infrared Applications. This subcommittee arranged a technical session for the Summer General Meeting. At present it is planned to extend the scope of this subcommittee to include industrial spectroscopy, thus broadening the base of its activities.

Electronic Preparation and Preservation of Food. This recently organized subcommittee is looking forward to activity in providing for presentation to the Institute of technical papers regarding progress in this field.

Magnetic Amplifiers. This new subcommittee was organized during the past year in recognition of the facts that magnetic amplifiers recently have become of substantial importance, that the circuit principles involved are basically the same as those in purely electronic circuits, and that nearly all magnetic amplifiers include important electron tube elements in their circuits. This subcommittee has arranged a technical session for the Summer General Meeting, and is maintaining a close liaison with the Committee on Basic Sciences. Standards activities are being planned.

Electronic Applications of Semiconductors. It is the responsibility of this newly organized subcommittee to give adequate attention, in the way of technical sessions and papers within the AIEE, to engineering applications to the newer solid-state devices, including transistors, crystal rectifiers, and related devices. Standards activities are under consideration.

COMMITTEE ON INSTRUMENTS AND MEASUREMENTS

Because measurement is fundamental to scientific progress, the activities of the committee are related to all branches of Institute work, and close liaison is paramount. The work of the committee has been aimed at the stimulation of interest in instruments and measurements and the co-ordination of effort in this field, including the preparation of appropriate Standards. To keep pace with the expansion of the measuring art, the membership was increased to 49. Meetings were held on November 9, 1948, and March 30, 1949. The latter was at the National Bureau of Standards, with Dr. F. B. Silsbee as host, and included an inspection trip of a number of the laboratories of the Bureau of Standards, as well as a visit to the Naval Ordnance Laboratory the following day.

About 50 technical and conference papers were presented during the year under the auspices of the main committee and its direct subcommittees, and about 50 additional papers were sponsored by the joint subcommittees. The range of subject matter testifies to the extreme diversity of measurement work.

In considerable measure, the instruments and measurements work is carried out through nine subcommittees whose activities have been as follows:

Subcommittee on Revision of Standard 4 (Measurement of Test Voltage in Dielectric Tests). The most important item on the program of this subcommittee is the standardization of methods for short-time impulse measurements. This problem is being studied by the NEMA Laboratory Co-ordination Subcommittee.

Subcommittee on Revision of C39 (Electrical Indicating Instruments). This subcommittee has co-operated with the ASA subcommittee on the revision of the C39 Standard. The first part of the Standard, covering switchboard and panel instruments, has been approved by ASA and printed for general distribution. Work on the second part, covering portable and laboratory standard-type instruments, is nearing completion.

Subcommittee on Master Test Code for Resistance Measurements. A revised draft of the trial code published in September 1947 is being circulated for approval of the Standards Committee and final printing.

Subcommittee on Master Test Code for Temperature Measurements. A proposed new code was published in October 1948 for one year's trial use.

Subcommittee on Marking of Varmeters and Related Instruments. A questionnaire has been circulated to obtain data on present practices regarding the connection and scale markings of the varmeter and related instruments. Further activities of the subcommittee will be based on the results of this survey.

Subcommittee on Watt-Hour Meters. This subcommittee sponsored nine technical and conference papers.

Subcommittee on Electrical Tests on Dielectrics in the Field. This subcommittee sponsored two sessions at the Winter General Meeting, at which eight conference papers were presented.

Subcommittee on High-Frequency Measurements. This subcommittee was responsible for planning the Conference on High-Frequency Measurements, held in Washington, D. C., January 10–12, 1949, under the joint sponsorship of AIEE, IRE, and the National Bureau of Standards. Attendance totaled 584. The community of interest in the subject gave rise to animated discussion.

Subcommittee on Definitions. The activities of this subcommittee have been limited to review of the definitions prepared by Subcommittee 6 of ASA C42.

Necessary co-ordination with the work of the other technical committees of the Institute is achieved through a number of joint subcommittees and in some instances, by cross representation. The increasing number of technical committees has augmented the problem of maintaining proper liaison. While present arrangements have proved highly satisfactory, a study is being made of intercommittee relationships to see whether any modifications in the existing scheme might be advantageous. The activities of the joint subcommittees are summarized in the following:

Joint Subcommittee on Electronic Instruments. This subcommittee sponsored two sessions at the Winter General Meeting. Work is underway on the development of specifications for the performance of vacuum tube voltmeters and cathode-ray oscilloscopes.

Joint Subcommittee on Servomechanisms. This subcommittee sponsored one session at the Winter General Meeting.

Joint Subcommittee on Nucleonic Instruments. This subcommittee, in co-operation with the Committee on Nucleonics and the Committee on Electronics Subcommittee on Electronic Aids to Medicine, sponsored a joint AIEE-IRE Conference on Electronic Instrumentation in Nucleonics and Medicine in New York, N. Y., November 29–December 1, 1948. The conference was quite successful with a total attendance of 540. Also, the subcommittee sponsored sessions at the Pacific General Meeting and the Midwest General Meeting.

Joint Subcommittee on Telemetering. A revision of the October 1941 report on "Telemetering, Supervisory Control, and Associated Circuits," has been issued. Three technical papers were sponsored by the subcommittee.

Joint Subcommittee on Instrument Transformers. Working groups are active on current transformers, test code, and rating factors.

COMMITTEE ON NUCLEONICS

This committee continued its activities in the field of nucleonics with a membership of approximately 25, and with four subcommittees as follows: Joint Subcommittee on Nucleonic Instruments (Joint with Committee on Instruments and Measurements); Subcommittee on Isotopic Tracers; Subcommittee on Safety and Health Protection Against Radiation; Subcommittee on Nuclear Physics.

Committee meetings were held in Spokane, Wash., Washington, D. C., and New York, N. Y., and a meeting of the committee officers and subcommittee chairmen was held in Cambridge, Mass., on August 10, 1948.

The committee activities were directed mainly toward bringing nucleonic information to the Institute membership, and thus stimulating interest in this field in which the electrical engineer must play an increasingly important part. To this end the following meetings were arranged.

Conference session at Pacific General Meeting, with four papers covering health physics, nucleonic instruments, accelerators, and atomic power reactors, sponsored by the Subcommittee on Nucleonic Instruments.

Conference session at Middle Eastern District Meeting, with four papers by different authors covering the same subjects for the different audience, sponsored by the Subcommittee on Nucleonic Instruments.

Conference session at the Winter General Meeting, with four papers covering health physics, and industrial and research applications and techniques for radioactive tracers, sponsored by the Subcommittees on Isotopic Tracers and on Safety and Health Protection.

Conference session at South West District Meeting, with three papers covering accelerators and radioactive tracer applications in medicine and biology, sponsored by the Subcommittee on Nuclear Physics.

Joint AIEE-IRE Conference on Electronic Instrumentation in Nucleonics and Medicine held in the Engineering Societies' Building, in New York, on November 29, 30, and December 1, with 26 papers.

The last-named meeting was sponsored jointly with the Committee on Electronics Subcommittee on Electronic Aids to Medicine, in co-operation with the Institute of Radio Engineers. Approximately 540 people attended. The program was well received. A questionnaire was sent to those who attended, and, on the basis of replies, it has been decided that a similar conference should be held in 1949.

In addition to meetings, the committee sponsored the publication of additional papers on nucleonic subjects, and the nucleonic series in *Electrical Engineering* was completed. A bibliography was prepared covering other literature on the subject, and the complete series has been published in pamphlet form under the title "Elements of Nucleonics for Engineers."

Finally, the committee participated in arrangements for the co-ordination of the various glossaries on nucleonics under the National Research Council, and is collaborating on the preparation of the section on instrumentation.

General Applications Group

COMMITTEE ON AIR TRANSPORTATION

The Committee on Air Transportation held one meeting of the entire committee during the year. This meeting was held in Washington on the occasion of the Middle Eastern District Meeting. The activities of the committee for the coming year in the field of Standards were discussed, and plans were made for technical sessions at the 1949 Pacific General Meeting. Because of the wide geographical spread of the electrical engineers interested in aircraft transportation, it is thought that technical sessions on this subject should be concentrated at one principal meeting during the year. For this reason it is planned to concentrate efforts on technical papers at the coming Pacific General Meeting. The Standards activities of the committee are carried on by its several subcommittees, and the status of the committee's work is described under the headings of the several subcommittees in the following paragraphs.

Aircraft Electric Rotating Machinery. The "Proposed Test Code for D-C Aircraft Electric Rotating Machines," AIEE Report 800, which was issued in March 1947 for one year's trial use, is being revised for reissue. It was thought that in the present form this report was not ready for standardization in the form of a test code, and it is expected that this will be available for reissue within the next few months.

Joint Subcommittee on Carbon Brushes. This subcommittee, which is joint with the Committee on Rotating Machinery and the Committee on Air Transportation, was formed for the purpose of writing a code for testing carbon brushes and brush materials. It made an interim report at the recent Winter General Meeting. At that time, a recommendation was made that the present subcommittee be disbanded and a new joint subcommittee formed with the fore-named AIEE committees and the Carbon Brush Committee of the NEMA Technical Committee. This action now is awaiting the approval of the Standards Committee. It is hoped that the new joint subcommittee may be completed at an early date.

Aircraft Electrical Control, Protective Devices, and Cable. This subcommittee has prepared a "Proposed Test Code for Aircraft Circuit Interrupting Devices (12-, 24-, and 120-Volt D-C Systems)," which has been submitted to the Committee on Air Transportation for approval, with the view of recommending it to the Standards Committee for issue for one year's trial use. This subcommittee also is preparing a test code for aircraft generator voltage regulators. It is expected that this code also will be issued for one year's trial use by the industry before being proposed as a Standard. This subcommittee is planning next to prepare a code for testing the interrupting capacity of aircraft d-c circuit breakers. It is expected also that this group will undertake the preparation of a report on the "Recommended Practice for the Installation and Protection of Electric Wiring in Aircraft."

Basic Principles of Altitude Rating. This subcommittee has been assigned the task of preparing an AIEE Standard on the basic principles of altitude rating of electric machinery. It is expected that this rating will extend the altitude considerations to 50,000 feet and take into consideration such factors as temperature, pressure, and humidity, and will furnish data for determining safe rating of aircraft electric machinery. It is planned that a survey will be conducted of the users of altitude chambers to determine the correlation of data obtained in flight with that obtained in altitude chambers, and it is hoped that this survey may result in a more unified practice in the use of altitude chambers.

Aircraft Electric Systems. This subcommittee was engaged in the preparation of new material for inclusion in the report "Report on Aircraft Electric System Guide," AIEE 750, which was published in July 1947. The guide was issued in an incomplete state, and it is expected that revision will be a continual process in order that it may be kept up to date in regard to aircraft electric system development. It is planned that other subcommittees will furnish information pertaining to their assigned fields of activity for inclusion in the "Systems Guide."

COMMITTEE ON DOMESTIC AND COMMERCIAL APPLICATIONS

The committee has been active in the preparation and presentation of papers, and in promoting a greater awareness among the engineers in the appliance field both of the value of the Institute and of the part which appliance engineers play in developments in the electrical industry.

The scope of the Committee on Domestic and Commercial Applications is such that the engineering requirements do not lend themselves readily to standardization such as is normally considered within the field of the Institute's activities. As a consequence, no work on Standards has been conducted or contemplated. Many excellent papers have been prepared, however, and presented at various Institute meetings. Papers were presented at the Summer General Meeting and at the Midwest General Meeting, and a symposium of six papers on the control and protection of household electric equipment was held at the Winter General Meeting.

All sessions where papers were presented under the auspices of this committee were well attended, and four of the papers were

considered to be of sufficient general interest to be acceptable for publication in *Electrical Engineering*.

Interest in the program sponsored by the committee resulted in six engineers affiliating with the Institute and the renewal of activity on the part of members in several Districts who had believed that their particular field was not adequately covered.

COMMITTEE ON LAND TRANSPORTATION

The committee held one well-attended and very full business meeting on February 1, 1949. At this meeting, the committee heard a very interesting discussion by T.M.C. Martin on the question "Will Complete Dieselization Save Oil?" The following activities also were discussed and organized.

Technical Meetings. Two transportation papers were presented at the Summer General Meeting, and four were presented at the Midwest General Meeting. These related to short-time ratings of diesel-electric locomotives, energy sources for railroad motive power, head end power on railroad passenger trains, and handling of suburban traffic on steam railroads. Seven papers were presented at the Winter General Meeting. These covered application of diesel-electric locomotives, 25 years progress in the design of traction motors (report on the progress of the art), the renaissance of the electric motive power, the electric equipment for Chesapeake and Ohio steam turbine-electric locomotives, selenium rectifiers in motor vehicle power systems, trackless trolley operations in Rhode Island, and a review of cities where trolley coaches have replaced busses.

Subcommittee Activities. The review of AIEE Standard 16, "Standards for Electric Railway Control Apparatus," has been completed, and this Standard now includes coverage of the electric portions of the electropneumatic brake system. This Standard is being issued for trial use.

COMMITTEE ON PRODUCTION AND APPLICATION OF LIGHT

One meeting of the entire committee was held. This meeting was held at the Winter General Meeting. A conference on fluorescent lighting, which was sponsored by the committee, was held on the afternoon of the same day. One of the subjects which was discussed at the committee meeting was the scope of the committee's activities. As a result of this discussion, it was concluded that one of the primary objectives is to keep AIEE membership advised on lighting matters, by encouraging meetings on the subject at general meetings, and Section meetings. Earlier in the year, the chairman had proposed to the Sections Committee that a list of speakers available for various local activities be distributed to the Sections. The Sections Committee had responded by indicating that it would like to consider the inauguration of such a procedure for all technical committees.

Reports were presented on the activities of the following subcommittees:

Subcommittee on Ultraviolet Radiation. This subcommittee has been working on a paper giving general background material on ultraviolet radiations. The manuscript was distributed to the committee, and several suggestions made for bringing it to completion.

Subcommittee on Infrared Radiation. This subcommittee is working in co-operation with two other AIEE infrared subcommittees: Radiant Heating Subcommittee under the Committee on Electric Heating; Infrared Applications Subcommittee under the Committee on Electronics. This subcommittee will encourage the use of electric infrared radiation for those processes for which it is suitable, by the collection and dissemination of available data, as well as the encouragement of new research. Investigations are being carried on at the present time on infrared sources, techniques, and measuring instruments. A program is also under way for the collection of fundamental application data.

Subcommittee on Nomenclature of Electric Discharge Lamps. The report which had been prepared by this subcommittee had been circulated to members of the committee prior to the meeting. A number of written comment had been received, and these were discussed, together with other comments which were brought in by other committee members or evolved out of the discussion. The chairman of the subcommittee agreed to prepare an additional draft, incorporating the suggestions which the committee had agreed should be included. The final draft should be ready for circulation shortly.

COMMITTEE ON MARINE TRANSPORTATION

Two well-attended meetings of the committee were held at Institute headquarters, one in January, and one in April, 1949.

The latest revision of "Recommended Practice for Electrical Installation on Shipboard," was issued in December 1948. The committee has been working on the matter of international standardization of electrical installation on shipboard. This work was delegated to the Committee on Marine Transportation by action of the Board of Directors of the Institute.

Technical Meeting. Four marine transportation sessions were held at the Middle Eastern District Meeting. The sessions were very well attended, each having from 50 to 125 people present. The first session covered the subjects of insulating materials and magnetic amplifiers, and the second covered the subjects of circuit breakers and shipboard degaussing installations. Three papers were presented at each. The third session covered the subject of power on shipboard, with four papers presented and discussed. The fourth session covered the subject of shipboard lighting, with three papers presented and discussed. These sessions all created considerable interest in the work of the committee.

Subcommittee Activities. These subcommittees have been quite active, each reviewing the sections of Standards 45 under its cognizance, and making reports to the main committee.

Awards

COMMITTEE ON AWARD OF INSTITUTE PRIZES

On account of the adoption of the new rules, with a shift from the calendar year to the administrative year, no awards were made this spring. The committee held one meeting for consideration of the proposed changes in rules submitted by a subcommittee of the Sections Committee, and will consider the proposals again when they are in final form.

CHARLES LEGEYT FORTESCUE FELLOWSHIP

During the year, one meeting of the committee was held to select the recipient of the Fortescue Fellowship award for the scholastic year 1949–50. One full fellowship of $1,500 was awarded to E. F. Koncel, Jr. A continuing fellowship in the amount of $500 was awarded to last year's recipient to assist him in completing the second year of his graduate work.

Consideration is being given to several proposals to arouse more interest on the part of faculty members so that competition for this fellowship will be more widespread.

COMMITTEE ON MEMBERS-FOR-LIFE FUND

The committee took no further action during the past year. The Board of Directors approved its recommendations that a statement regarding the use of the fund be published in *Electrical Engineering* and mailed to each new Member-for-Life with the notification; that a specially designed card be mailed to all living Members-for-Life and in the future be mailed with the official notice; and that, when the growth of the fund warrants, prize winners from all Districts be included in the provision for traveling expense allowance to the Summer General Meeting.

EDISON MEDAL

The Edison Medal for 1948 was awarded to Dr. Morris E. Leeds, Chairman of the Board, Leeds and Northrup Company, Philadelphia, Pa., "for his contributions to the industry through development and production of electrical precision measuring devices and controls," and was presented to him on February 2, 1949, in a general session of the Winter General Meeting.

The medal may be awarded annually for meritorious achievement in electrical science, electrical engineering, or the electrical arts. Awards are made by a committee of 24 members of the Institute.

LAMME MEDAL

The Lamme Medal for 1948 was awarded to Dr. V. K. Zworykin, Vice-President and Technical Consultant of the RCA Laboratories Division, Radio Corporation of America, Princeton, N. J., "for his outstanding contribution to the concept and design of electronic apparatus basic to modern television." The medal will be presented to him on June 22, 1949, during the Summer General Meeting.

The medal may be awarded annually by a committee of nine members to a member of the AIEE for "meritorious achievement in the development of electrical apparatus or machinery."

HOOVER MEDAL

The Hoover Medal is awarded periodically to an engineer for distinguished public service by a board representing the American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, American Society of Mechanical Engineers, and AIEE. The medal was awarded, in 1948, to Malcolm Pirnie, Consulting Engineer, New York, N. Y., with a citation as: "Engineer, leader of engineers and servant of his fellowman, whose ideals and accomplishments in public life beyond the call of his profession have benefited men in his own and other countries of the world." The medal was presented to him on January 19, 1949, at the annual meeting of the ASCE, of which he is a past president.

JOHN FRITZ MEDAL

The John Fritz Medal may be awarded annually for notable scientific or industrial achievements, by a board of award composed of representatives of the ASCE, AIME, ASME, and AIEE. The 1949 medal was awarded to Charles M. Allen, Professor Emeritus of Hydraulic Engineering, Worcester Polytechnic Institute, with the citation:

"Exceptional achievements in hydraulic engineering. Founder of notable hydraulic laboratory; prominent teacher, consultant, inventor and author." The medal was presented to him on January 19, 1949, at the annual meeting of the ASCE.

MARSTON MEDAL

The Marston Gold Medal is awarded to an alumnus of Iowa State College, of at least 30 years' standing, for achievement in engineering in a broad field. The board of award includes representatives of the college, and five engineering societies: ASCE, AIME, ASME, AIEE, and AIChE. The 1948 award was to Roy W. Crum, Director of the Highway Research Board of the National Research Council, Washington, D. C.

WASHINGTON AWARD

The Washington Award for 1949 was made to John L. Savage, Consulting Engineer, Tennessee Valley Authority, and Chief Designing Engineer, United States Bureau of Reclamation, Denver, Colo. The award is made annually to an outstanding engineer, a citizen or resident of the United States, who ably has served human needs, and is administered by a commission representing the Western Society of Engineers, ASCE, AIME, ASME, and AIEE.

ALFRED NOBLE PRIZE

This prize was established in 1929 to perpetuate the name and achievements of Alfred Noble, Past President of the ASCE and the Western Society of Engineers. It may be made to a member of any of the cooperating societies, ASCE, AIME, ASME, AIEE, or WSE, for a technical paper of particular merit accepted by the publication committee of any of these societies, provided the author is not more than 30 years of age at the time of such acceptance.

Joint Activities

UNITED ENGINEERING TRUSTEES, INC.

The funds and property held jointly by the four Founder Societies, including the Engineering Societies Building, the Engineering Societies Library, and the endowment funds of the Engineering Foundation, are administered by the United Engineering Trustees, Inc., which also serves as treasurer of the Engineers' Council for Professional Development.

The building has recently required some major repairs. It is fully occupied at present, and two of the Founder Societies have substantial amounts of space in other buildings.

ENGINEERING FOUNDATION

The Engineering Foundation is a department of the United Engineering Trustees, Inc., and its general objective is "the furtherance of research in science and engineering."

With the income from its endowment funds, it supports a broad range of research projects, now numbering about 16. Some of its most effective contributions are those supporting studies and analyses necessary in the early stages of organizing projects on such bases that financial support from other sources becomes available. A special study is being devoted to the future employment of Foundation funds towards advancing research.

ENGINEERING SOCIETIES LIBRARY

The library is a department of the United Engineering Trustees, Inc., and was formed by combining the separate libraries of the ASCE, AIME, ASME, and AIEE, and is conducted as a free public reference library.

In addition to affording the use of a large collection of engineering books and periodicals, the library renders special services such as bibliographies, translations, photostats, searches, and book loans by mail.

A broad survey is in progress for the purpose of reorienting the library with other technical libraries in the United States and for obtaining greater financial support. The bylaws governing the Library Board have been amended to reduce the number of board members from 22 to 12.

ENGINEERS' COUNCIL FOR PROFESSIONAL DEVELOPMENT

The principal activities of ECPD include programs for the guidance of young persons thinking of entering the engineering field, the accrediting of curricula of engineering schools, and encouragement and assistance to individuals in their engineering and cultural studies during several years following graduation. The council represents ASCE, AIME, ASME, AIEE, American Institute of Chemical Engineers, the Engineering Institute of Canada, the American Society for Engineering Education, and the National Council of State Boards of Engineering Examiners.

ENGINEERS JOINT COUNCIL

The membership of this council includes the two most recent available past presidents and the secretaries, also the presidents as ex-officio members without votes, of the five member societies; ASCE, AIME, ASCE, AIEE, and AIChE. Its purpose is to promote co-operation among the branches of engineering by seeking and studying matters of mutual interest to the member societies, to recommend joint action, and to administer activities authorized by a majority of the societies. A constitution was recently adopted and referred to the societies for approval.

REPRESENTATIVES

A complete list of about 40 joint bodies upon which the Institute is represented appears in the Year Book and in the October issue of *Electrical Engineering* each year.

Appreciation

The continuing rapid increase in the membership and the income of the Institute are tangible symbols of the highly effective work of the national committees, and the District, Section, and Branch officers and committees. For their enthusiasm and excellent co-operation, the Board of Directors expresses sincere thanks and appreciation. It also thanks the members in general for their keen interest in the activities and for their splendid support of established policies.

Respectfully submitted for the Board of Directors.

H. H. HENLINE
Secretary

HASKINS & SELLS
CERTIFIED PUBLIC ACCOUNTANTS

1 EAST 44TH STREET
NEW YORK 17

ACCOUNTANTS' CERTIFICATE

American Institute of Electrical Engineers:

We have examined the balance sheet of American Institute of Electrical Engineers, and schedule of securities owned, as of April 30, 1949, and the related statements of cash receipts and disbursements of operating and restricted funds for the year then ended. Our examination was made in accordance with generally accepted auditing standards, and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

In our opinion, the accompanying balance sheet, schedule of securities owned, and statements of cash receipts and disbursements, respectively, present fairly the financial position of, and securities owned by, the Institute at April 30, 1949, and its recorded cash receipts and cash disbursements for the year then ended, in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

(*Signed*) HASKINS & SELLS

New York,
May 19, 1949

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Balance Sheet, April 30, 1949

Exhibit A

ASSETS			LIABILITIES		
Property Fund Assets:			**Property Fund Reserve**		$ 553,562.37
One-fourth interest in physical properties of United Engineering Trustees, Inc.:			**Restricted Fund Reserves:**		
Land, buildings, and equipment (less depreciation and renewal reserve)	$332,383.85		Reserve capital fund	$531,660.79	
Funded depreciation and renewal reserve	166,064.63		Life membership fund	8,312.51	
Total	$498,448.48		Member-for-Life fund	9,632.17	
Equipment:			International Electrical Congress of St. Louis library fund	6,442.30	
Library (volumes and fixtures)—estimated value	36,366.37		Lamme Medal fund	4,440.44	
Office furniture and fixtures (less reserve for depreciation, $31,567.26)	15,746.17		Mailloux fund	1,012.15	
Works of art, etc.	3,001.35		Volta Memorial fund	18,908.67	
Total property fund assets		$ 553,562.37	Total restricted fund reserves		580,409.03
Restricted Fund Assets:			**Operating Fund Reserves, Liabilities, etc.:**		
Securities—at cost, less reserve, $1,788.15 (quoted market value, $533,172.52)—Schedule 1	$523,824.26		Accounts payable	$ 30,007.57	
Cash (Exhibit *C*)	56,399.79		Deferred income:		
Accrued interest receivable	184.98		Dues received in advance	3,501.36	
Total restricted fund assets		580,409.03	Entrance fees and dues advanced by applicants for membership	2,309.08	
Operating Fund Assets:			Subscriptions to publications received in advance	20,597.00	
Cash (not including $1,674.87 for Federal taxes withheld from employees)—(Exhibit *B*)	$14,795.59		Miscellaneous (including unallocated receipts)	1,753.57	
Accounts receivable:			Operating fund reserves	22,818.35	
Members—for dues (less reserve, $5,750.00)	11,675.34		Total operating fund reserves, liabilities, etc.		80,986.93
Advertisers	2,572.37				
Miscellaneous	6,638.63				
Technical Conference loans outstanding	650.00				
Accrued interest receivable	2,042.33				
Inventories:					
Transactions, etc.	1,308.00				
"Electrical Definitions"	537.00				
Work in process *Transactions* (Part II 1948), etc.	5,726.96				
Text and cover paper	11,311.46				
Badges	7,601.64				
Deferred charges—Production charges for May issue of *Electrical Engineering*	16,127.61				
Total operating fund assets		80,986.93			
Total		$1,214,958.33	Total		$1,214,958.33

Exhibit B — Statement of Cash Receipts and Disbursements of Operating Fund for the Year Ended April 30, 1949

Cash on Deposit with The National City Bank of New York, May 1, 1948 (not including $2,031.98 for Federal taxes withheld from employees)		$ 22,394.58
Receipts:		
Dues (including $168,882.00 allocated to *Electrical Engineering* subscriptions)	$363,816.95	
Advertising in *Electrical Engineering*	169,325.25	
Transactions subscriptions	15,874.93	
Electrical Engineering subscriptions	30,662.92	
Miscellaneous publications (preprints, Standards, special reports, etc.)	49,246.60	
Students' fees	39,356.25	
Entrance fees	19,584.56	
Registration fees—Institute Meetings and Technical Conferences	13,585.71	
Membership badges	5,264.20	
Transfer fees	3,440.00	
Interest and dividends on investments of Reserve Capital Fund	29,958.02	
Miscellaneous	496.90	
Total	$740,612.29	
Refund from Radio Technical Planning Board	722.28	
Refund of expenses paid, 1947 Summer General Meeting	53.03	
Contribution from Committee on Instrumentation and Measurements	94.00	
Transfer from Property Fund	612.91	
Transfer from Reserve Capital Fund—net (see Exhibit *C*)	11,817.00	
Total receipts		753,911.51
Total		$776,306.09
Disbursements:		
Publications expense:		
Electrical Engineering text	$175,472.46	
Electrical Engineering advertising	93,594.98	$269,067.44
Transactions	21,166.69	
Proceedings	37,636.58	
"Year Book"	12,168.99	
Special publications	2,528.15	
Miscellaneous publications (preprints, Standards, etc.)	32,498.14	
Institute meetings	32,396.51	
Institute Sections	91,039.35	
Institute Branches, including prizes, etc.	7,706.99	
Finance Committee	850.00	
Headquarters Committee	344.86	
Membership Committee	19,512.63	
Standards Committee	20,711.33	
Technical Committees	11,684.65	
Committee on Public Relations	1,183.88	
Edison Medal Committee	296.51	
Forward	$560,792.70	
Total (forward)		$776,306.09
Total (forward)		$776,306.09
Disbursements (forward)	$560,792.70	
Traveling expenses:		
Geographical Districts: Executive committees	6,278.69	
Vice-Presidents	1,770.67	
Conferences on Student activities	8,783.72	
Board of Directors	15,750.87	
Nominating Committee	1,568.85	
President's appropriation	4,294.33	
Administrative expenses	90,436.12	
Geographical Districts—Branch paper prizes	100.11	
Institute prizes—National	532.70	
Retirement system AIEE—normal contribution	8,395.31	
American Standards Association	1,875.00	
Canadian Radio Technical Planning Board	10.00	
Canadian Council of Professional Engineers and Scientists	278.71	
Engineers' Council for Professional Development	1,808.50	
Engineering Foundation Project—Welding research	250.00	
Engineers Joint Council—General expenses	759.50	
John Fritz Medal	75.00	
National Committee State Board Engineering Examiners	500.00	
U. S. National Committee—International Commission on Illumination	300.00	
Constitution and Bylaws Committee	1,152.48	
United Engineering Trustees, Inc.:		
Building assessments	19,547.48	
Library assessments	13,053.35	
Library Retirement Plan	3,615.43	
Lamme Medal expense (see Exhibit *C*)	124.30	
Membership badges	5,768.42	
Legal services	987.53	
Office furniture and fixtures and repairs	3,067.03	
Rent, etc., Editorial Department, 500 Fifth Avenue	6,963.30	
Total	$758,840.10	
Transfer to Member-for-Life fund	2,020.40	
Technical Conference—Loans outstanding	650.00	
Total disbursements		761,510.50
Cash on Deposit, April 30, 1949:		
The National City Bank of New York (not including $1,674.87 for Federal taxes withheld from employees)	$ 12,441.23	
The Canadian Bank of Commerce, Toronto	2,354.36	$ 14,795.59

Exhibit C — Statement of Cash Receipts and Disbursements of Restricted Funds for the Year Ended April 30, 1949

	Total	Restricted Funds: Reserve Capital Fund	Member-for-Life Fund	Life Membership Fund	International Electrical Congress of St. Louis Library Fund	Lamme Medal Fund	Mailloux Fund	Volta Memorial Fund
Cash on Deposit With The National City Bank of New York and Various Savings Banks, May 1, 1948	$ 39,398.08	$ 25,489.06	$ 8,416.86	$3,435.68	$ 891.47	$150.00	$1,015.01	
Receipts:								
Proceeds from sales, etc. of securities	$ 82,902.20	$ 82,902.20						
Income from bonds	545.34		$ 62.50	$ 127.56	$ 135.28	$160.00		$ 60.00
Interest on bank balances	63.14			48.00			$ 15.14	
Transfer from operating fund	1,957.90	1,957.90						
Life membership fees	209.56			209.56				
Gift from Italy America Society, Incorporated	16,759.51							16,759.51
Total receipts	$102,437.65	$ 82,902.20	$ 2,023.40	$ 385.12	$ 135.28	$160.00	$ 15.14	$16,819.51
Total	$141,835.73	$108,391.26	$10,437.26	$3,820.80	$1,026.75	$310.00	$1,030.15	$16,819.51
Disbursements:								
Purchase of securities	$ 71,791.32	$ 66,791.32	$5,000.00					
Transfers to operating fund:								
To be repaid when adequate funds become available	11,817.00	11,817.00						
Other	709.36			$ 709.36				
Purchase of medal, cost of engraving, etc. (exclusive of $124.30 paid from operating fund)	150.00					$150.00		
Library purchases	111.09				$ 93.09		$ 18.00	
Traveling expenses	857.17		857.17					
Total disbursements	$ 85,435.94	$ 78,608.32	$5,857.17	$ 709.36	$ 93.09	$150.00	$ 18.00	
Cash on Deposit With The National City Bank of New York and Various Savings Banks, April 30, 1949	$ 56,399.79	$ 29,782.94	$4,580.09	$3,111.44	$ 933.66	$160.00	$1,012.15	$16,819.51

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Securities Owned, April 30, 1949

Schedule 1

	Principal Amount of Bonds or Number of Shares of Stock	Restricted Funds						
		Reserve Capital Fund	Life Membership Fund	Member for Life Fund	International Electrical Congress Library Fund	Lamme Medal Fund	Volta Memorial Fund	Total
Railroad Bonds:								
Atlantic Coast Line First Consolidated 4%, due 1952	$ 4,000.00					$4,253.78		$ 4,253.78
Baltimore & Ohio, Pittsburgh, Lake Erie & West Virginia System Refunding 4%, due 1980	10,000.00	$ 6,450.00						6,450.00
Chicago & Erie Railroad Company 5% first mortgage, due 1982, registered	1,000.00	1,105.00						1,105.00
New York Central Railroad Company 4% series *A* consolidated mortage, due 1998	15,000.00	9,812.50						9,812.50
Northern Pacific Railway Company 4½% collateral trust, due 1975	15,000.00	15,307.50						15,307.50
St. Louis-San Francisco Railway Company 4% series *A*, first mortgage, due 1997	1,200.00	1,200.00						1,200.00
St. Louis-San Francisco Railway Company 4% series *A*, first mortgage, scrip	198.00	198.00						198.00
St. Louis-San Francisco Railway Company 4½% series *A*, second mortgage income bonds, due 2022	1,300.00	1,300.00						1,300.00
St. Louis-San Francisco Railway Company 4½% series *A*, second mortgage income bonds, scrip	61.10	61.10						61.10
Total railroad bonds		$ 35,434.10				$4,253.78		$ 39,687.88
Public Utility Bonds:								
American Telephone & Telegraph Company 2¾% convertible debentures, due 1961	$40,000.00	$ 33,154.75	$5,153.12		$5,457.85			$ 43,765.72
Consolidated Edison Company of New York, Incorporated 3% convertible debentures, due 1963	25,000.00	27,281.25						27,281.25
Total public utility bonds		$ 60,436.00	$5,153.12		$5,457.85			$ 71,046.97
United States Government Bonds:								
Treasury bonds 2%, due March 15, 1952/50	$ 3,000.00	$ 3,074.22						$ 3,074.22
Treasury bonds 3%, due September 15, 1955/51	2,000.00						$2,081.66	2,081.66
Defense bonds series *G*, 2½%, due December 1, 1954	18,000.00	13,000.00		$5,000.00				18,000.00
Treasury Savings bonds series *G*, 2½%, due September 1, 1955	40,000.00	40,000.00						40,000.00
Treasury Savings bonds series *G*, 2½%, due November 1, 1956	17,000.00	17,000.00						17,000.00
Treasury Savings bonds series *G*, 2½%, due May 1, 1957	20,000.00	20,000.00						20,000.00
Treasury Savings bonds series *G*, 2½%, due October 1, 1957	30,000.00	30,000.00						30,000.00
Total United States Government bonds		$123,074.22		$5,000.00			$2,081.66	$130,155.88
Capital Stocks:								
American Can Company	60 shares	$ 4,988.40						$ 4,988.40
American Gas & Electric Company	400 shares	15,137.62						15,137.62
Atchison, Topeka & Santa Fe Railway Company preferred	200 shares	19,174.71						19,174.71
Atlantic City Electric Company	40 shares	612.00						612.00
Boston Edison Company	200 shares	4,927.50						4,927.50
Commonwealth Edison Company	200 shares	7,580.68						7,580.68
Consolidated Natural Gas Company	100 shares	4,428.80						4,428.80
Dow Chemical Company $4 cumulative preferred, series A	100 shares	11,547.50						11,547.50
Eastman Kodak Company	315 shares	10,694.11						10,694.11
E. I. du Pont de Nemours & Company	80 shares	13,096.68						13,096.68
General Electric Company	200 shares	7,748.66						7,748.66
General Motors Corporation $5 preferred	200 shares	25,820.00						25,820.00
General Motors Corporation	100 shares	4,235.53						4,235.53
Gulf Oil Corporation	200 shares	12,264.20						12,264.20
Insurance Company of North America	100 shares	10,847.50						10,847.50
International Harvester Company	300 shares	5,030.50						5,030.50
International Match Realization Co. capital stock	6 shares	1,788.15*						1,788.15*
Louisville & Nashville Railroad Company	100 shares	6,278.13						6,278.13
Ohio Edison Company 4.40% preferred	200 shares	21,279.25						21,279.25
Pacific Gas and Electric Company	200 shares	8,420.99						8,420.99
Public Service Electric and Gas Company $1.40 dividend preference common stock	370 shares	11,150.00						11,150.00
St. Louis-San Francisco Railway Company voting trust certificates for 5% series *A* preferred stock	21 1800/10000ths shares	582.75						582.75
St. Louis-San Francisco Railway Company voting trust certificates for common stock	42 6000/10000ths shares	357.00						357.00
Scoville Manufacturing Company 3.65% cumulative preferred	100 shares	10,111.25						10,111.25
Sears, Roebuck and Co.	400 shares	6,014.97						6,014.97
Socony Vacuum Oil Company	408 shares	8,381.20						8,381.20
Standard Oil Company of Indiana	200 shares	8,170.32						8,170.32
Standard Oil Company of New Jersey	212 39/100 shares	9,761.26						9,761.26
Texas Gulf Sulphur Company	34/100 shares	144.60						144.60
Union Carbide & Carbon Corporation	300 shares	7,277.42						7,277.42
United Fruit Company	300 shares	11,985.00						11,985.00
United States Steel Corporation 7% cumulative preferred	100 shares	14,885.00						14,885.00
Total capital stocks		$284,721.68						$284,721.68
Total		$503,666.00	$5,153.12	$5,000.00	$5,457.85	$4,253.78	$2,081.66	$525,612.41
* Less reserve in full for securities considered to be of doubtful value		1,788.15						1,788.15
Total Securities, Less Reserve		$501,877.85	$5,153.12	$5,000.00	$5,457.85	$4,253.78	$2,081.66	$523,824.26

OF CURRENT INTEREST

Electrical Utility Employment to Expand in Next Ten Years, According to Labor Report

Electrical utility systems are likely to add between 40,000 and 55,000 employees during the next decade, according to a United States Department of Labor report, an account of which appeared in the *Labor Information Bulletin*, June 1949.

Power production is expected to increase substantially because of strong demands for electricity, and large plant expansions are planned. (In early 1949, there were 335,000 on electrical utility pay rolls.)

The report points out that for many years there has been an almost uninterrupted upward trend in the consumption of electricity, even during the 1930's. During the war there was a tremendous expansion in the use of electric power. Since then, sales of electricity have risen to new peaks because of new residential and farm customers, new appliances, and continued high industrial consumption. Utility systems will have increased production capacity by more than 40 per cent by 1952, and further expansion is expected.

Since much of the increased output will go to present customers rather than to new ones, in many areas it will be mainly necessary to revamp and raise the power-carrying ability of the transmission lines and distribution systems, rather than to construct completely new lines. There will not be a proportionate increase in meter reading, billing, and other activities which are related to the number of customers. Because of these and other factors, utility systems usually can expand output with a relatively smaller increase in employment.

Development of atomic energy power plants to produce electricity is not expected to have much influence on the industry during the next 10 to 20 years. Even then the plants are not expected to have much effect on employment in the industry, since they involve primarily a substitution of one fuel for another. These are the principal conclusions of a Bureau of Labor Statistics report on "Employment Outlook in Electric Light and Power Occupations."

Privately owned systems now account for the bulk of employment, and most of the increase is therefore likely to occur in them, the bureau states. Systems in rapidly developing areas, including many sections in the western parts of the country, will show larger than average increases in production and employment.

Despite the large increase in the capacity of generating plants, there is expected to be only a small addition to the number of jobs for power-plant workers, including the boiler operators, turbine operators, and switchboard operators. Because of technological changes tending to displace existing substations and limit the number of new ones constructed, there will be few new jobs for substation operators. The extension of power lines to new customers and the changes in the lines to handle the expected higher output of electric power will require the employment of additional linemen and groundmen, the two largest occupations in the operating and maintenance departments of utilities.

Jobs for office and technical workers, who together account for almost 40 per cent of employment in the utility field, also are expected to increase. As many as 2,000 new electrical engineers will be added by utility systems. For many occupations, including electrical engineers, there will be more openings to replace workers leaving the occupations as a result of death and retirement than there will be new jobs.

The bureau's report (Bulletin number 944) may be obtained from the Superintendent of Documents, Washington 25, D. C., at 30 cents a copy.

Future Meetings of Other Societies

American Chemical Society. 116th National Meeting. September 19–23, 1949, Atlantic City, N. J.

American Gas Association. Annual Convention. October 17–20, 1949, Palmer House, Morrison Hotel, and Sherman Hotel, Chicago, Ill.

American Institute of Chemical Engineers. September 6–9, 1949, Mount Royal Hotel, Montreal, Quebec, Canada.

American Society of Mechanical Engineers. Fall meeting. September 28–30, 1949, Erie, Pa.

American Society for Testing Materials. West Coast Meeting. October 10–14, 1949, Fairmount Hotel, San Francisco, Calif.

American Standards Association. Annual Meeting. October 11–14, 1949, Waldorf-Astoria Hotel, New York, N. Y.

Illuminating Engineering Society. National Technical Conference. September 19–23, 1949, French Lick, Ind.

Institute of Radio Engineers—West Coast Electronic Manufacturers Association. Fifth Annual Pacific Electronic Exhibit. August 30–September 1, 1949, Civic Center, San Francisco, Calif.

Instrument Society of America. Annual meeting and exhibit. September 12–16, 1949, Municipal Auditorium, St. Louis, Mo.

Iowa Utilities Association Management Conference. October 10–11, 1949, Hotel Fort Des Moines, Des Moines, Iowa.

National Conference on Industrial Hydraulics. Fifth Annual Meeting. October 26–27, 1949, Sheraton Hotel, Chicago, Ill.

National Electronics Conference. September 26–28, 1949, Edgewater Beach Hotel, Chicago Ill.

National Safety Congress and Exposition. October 24–28, 1949, Stevens, Congress, and Morrison Hotels, Chicago, Ill.

National Television and Electrical Living Show. Second Annual Meeting. September 30–October 9, 1949, Chicago Coliseum, Chicago, Ill.

Scottish Industries Exhibition. September 1–17, 1949, Kelvin Hall, Glasgow, Scotland.

Society of Automotive Engineers. Aeronautic Meeting and Aircraft Display. October 5–8, 1949, Biltmore Hotel, Los Angeles, Calif.

100,000 Engineers to Get Questionnaires in Survey for Office of Naval Research

An evaluation of American engineering brain-power is now in progress. One hundred thousand engineers holding the grade of member or higher in 18 national professional engineering societies are slated to receive a 4-page questionnaire. Names, addresses, ages, professional qualifications, and other data obtained therefrom will be filed with the Office of Naval Research in the National Military Establishment.

This survey is the result of a conference held in Washington, D. C., last fall, which was attended by representatives from the Scientific Personnel Branch of the Office of Naval Research, the Engineers Joint Council, as well as delegates from other engineering agencies. The conferees discussed the need for a list of key engineers working in research, development, and other technical projects who might be called in to work on the scientific programs of the National Military Establishment.

Besides providing a valuable tool in the event of a national emergency, this file will point up weak spots in our resources of technical personnel, which should be strengthened by education, training, and other means. The large body of facts will be made available to private industrial, educational, and professional-society planning groups, and to others who will use them for legitimate purposes.

At the meeting, the Engineers Joint Council (EJC), as the largest joint agency of the engineering profession, was assigned to the task of collecting the personal and professional information. (The Engineers Joint Council comprises five societies: AIEE; the American Society of Mechanical Engineers; the American Society of Civil Engineers; the American Institute of Mining and Metallurgical Engineers; and the American Institute of Chemical Engineers.) Thereupon, the Council designated the American Society of Mechanical Engineers (ASME) as the contracting agent under an Office of Naval Research agreement. The 18 co-operating societies have addressed 100,000 questionnaires for their members of professional grade. ASME now is mailing them. After processing by ASME, the questionnaires will be filed with the Office of Naval Research. C. E. Davies, Secretary of ASME, is Chairman of the EJC committee conducting the survey. R. A. Wentworth, member of ASME, is survey director.

As the information contained therein will be of vital importance to the national welfare, those engineers who receive the questionnaire are urged to give it serious attention.

General Electric Opens New High-Voltage Laboratory

On June 23, 1949, the new General Electric High-Voltage Engineering Laboratory was opened at Pittsfield, Mass. Julius H. Hagenguth (M '44) is Engineer-in-Charge.

The new laboratory, costing more than $2,000,000, is in two sections. The high bay area is 165 by 95 by 85 feet high, with special precautions taken against dust by employing filters in the air intake, exhausting through roof ventilators, and using radiant heating with a minimum of vertical air currents. In this area are the two 5,000-kv impulse generators (maximum peak voltage 7,500 kv) shown in the illustration. These generators, each 44 feet high, can be connected in parallel to obtain a 60,000-ampere discharge, or connected in series to develop 10,000,000 volts (maximum peak voltage 15,000,000 volts) and a 50-foot arc. The generator in the foreground is mounted on a truck which is on a transfer track through a doorway 50 feet high and 14 feet wide for testing unusually large apparatus in the outdoor area or testing to an experimental line.

The low bay is a 3-story structure 215 by 84 by 55 feet high, which includes office space, a small lecture hall, photographic dark room, electrical–mechanical workshop, storage rooms, and a large air-conditioned room used for testing under controlled climate conditions. Altogether there are ten test areas, most of which have both impulse and 60-cycle equipment, the latter ranging between 100 kv–1,750 kv (rms) to ground, for testing the various kinds of apparatus in the several voltage classes.

The new laboratory with its modern facilities will enable General Electric engineers to extend their research of high-voltage phenomena such as corona, sparkover, dielectric breakdown, and lightning. Research and development work will be extended in the design and manufacture of high-voltage electric apparatus such as transformers, lightning arresters, capacitors, and bushings. This research will ultimately result in improved service continuity at lower cost.

The two 5,000-kv impulse generators (maximum peak voltage 7,500 kv) in the high bay of the new General Electric High-Voltage Engineering Laboratory at Pittsfield, Mass.

Two-Way Radio Checks Utility's High-Voltage Transmission Lines

Mobile service units equipped with 2-way radio now keep constant check on the entire high-voltage transmission network of American Gas and Electric Company. The utility's radio network has grown in three years from a single small experimental station to a network of 47 fixed stations and more than 500 radio-equipped trucks and cars, representing a total cost of $560,000. The network now covers all territories on, or adjacent to, American Gas and Electric's high-voltage lines, serving more than a million customers, in 2,000 communities in seven states.

The system's fixed radio stations, situated in buildings similar to commercial radio stations, operate on frequency modulation on a 31,460-kc channel. The mobile units give perfect reception and transmission within a radius of 20 miles from the fixed stations.

Height of the permanent masts needed to give this coverage is determined by use of a barrage balloon. The balloon raises an antenna to any height desired, to permit coverage testing by mobile units on the ground. Crews in the radio-equipped trucks can communicate not only with stations, but with each other. This makes possible rapid and exact location of trouble, anywhere in the system's lines, even beyond the range of the main stations.

Use of the 2-way radio makes practical aerial patrolling of the system's lines. An observer in an airplane spots broken insulators, untrimmed trees, and other conditions dangerous to the lines, and reports them to the service crews by radio. The airplane requires only a low-power transmitter, since any desired coverage can be obtained merely by flying at a higher altitude.

Instrument Maintenance Clinic Will Be Held in St. Louis

A 3-day clinic on the maintenance of industrial instruments has been scheduled by the Instrument Society of America for September 9–12 in the Statler Hotel, St. Louis, Mo. More than 300 instrument men will participate in the clinic. Arrangements for transportation by chartered busses and airplanes are being made.

The clinic will be held in advance of the Fourth National Instrument Conference and Exhibit, sponsored by the Instrument Society of America, in co-operation with the Industrial Instruments and Regulators Division, American Society of Mechanical Engineers; Instruments and Measurements Committee, American Institute of Electrical Engineers; American Institute of Physics; Institute of Radio Engineers; National Telemetering Forum; and the Scientific Apparatus Makers Association. The expected attendance at the exhibit will exceed 10,000.

About 30 technical sessions will be held during the week and will cover every specific phase of instrumentation in science and industry.

Paper on Venezuelan Power Available. A manuscript, titled "Development of Electric Power in Venezuela," by David J. Morales, has been placed on file in the Engineering Societies' Library. Those interested in the paper should contact the library at 29 West 39th Street, New York 18, N. Y.

Egloff Heads Western Society of Engineers. Gustav Egloff, petroleum technologist and director of research for the Universal Oil Products Company, Chicago, Ill., has been elected to the presidency of the Western Society of Engineers at the annual election. In 1940, Dr. Egloff received the Octave Chanute Medal of the Western Society of Engineers, as well as the Gold Medal of the American Institute of Chemists. The National Research Council awarded him its Distinguished Service Award in 1941, and he received a Citation from the War Department in 1946. Other officers elected were: H. P. Sedwick (Vice-President of Public Service Company of Northern Illinois), First Vice-President; J. C. Witt (Chicago consulting engineer), Second Vice-President; Donald N. Becker (chief structural engineer for A. J. Boynton and Company), treasurer; Ludwig Skog (senior partner in the firm of Sargent and Lundy, consulting engineers), and L. F. Bernhard (cost study engineer of Illinois Bell Telephone Company), trustees for three years. The society's new headquarters are at 84 East Randolph Street, Chicago.

Hunter, Rensselaer Dean, Retires. Dr. Matthew A. Hunter is retiring as Dean of Faculty after 40 years of service at Rens-

Detroit's Transformer

This 3-phase 145,000-kva transformer, the most powerful ever built, is shown being lowered into the test pit at the transformer plant of the Westinghouse Electric Corporation, Sharon, Pa. for final tests before shipping. It recently was shipped to the Detroit (Mich.) Edison Company where it will convert generation voltage of 15,000 volts to 135,000 volts for transmission service

selaer Polytechnic Institute, Troy, N. Y. He was born in Auckland, New Zealand, in 1878. He received a bachelor's degree in science from Auckland University College in 1900, and a master of arts degree in 1901. He then went to England and was awarded a doctor of science degree from University College, London, in 1904. He continued his studies at the University of Gottingen, Germany, at the Sorbonne in Paris, and the Techniche Hochschule at Karlsruhe. Dr. Hunter came to the United States in 1905 and went to work in the General Electric Company's research laboratory in Schenectady, N. Y. In 1908, he joined the staff of Rensselaer Polytechnic Institute as a professor in electrochemistry. He has been associated with the institute ever since, having served as head of the Department of Electrical Engineering, the Department of Physics, and the Department of Metallurgical Engineering. He was head of the last department at the time of his appointment as Dean of Faculty in the fall of 1943.

Edgar B. Ingraham Receives McGraw Award. Edgar B. Ingraham, president of the National Electrical Wholesalers Association, has been presented the James H. McGraw Award Wholesalers Medal for 1948. He received the award "for his inspiring leadership of his industry in forming and developing the Appliance Division of the National Electrical Wholesalers Association and his vigorous efforts to advance the economic position of the electrical wholesaler." Twenty-three years ago, the late James H. McGraw, founder of the McGraw-Hill Publishing Company, Inc., established a series of four awards to encourage constructive thinking for the advancement of the electrical industry. Consisting each of a bronze medal and a purse of one hundred dollars, they are given for personal contributions of merit in the manufacturing, contracting, and wholesaling branches of the electrical industry. An endowment of $40,000 to perpetuate these awards is administered by a Committee of Awards representative of the industry.

Speakman Named to RDB Electronics Committee. Edwin A. Speakman has been appointed Executive Director, the Committee on Electronics, Research and Development Board, National Military Establishment. Mr. Speakman has been associated with the Naval Research Laboratory since 1940 and has been branch head of the Radio Counter-Measures Section since 1945. While attending Haverford (Pa.) College, from which he was graduated in 1931 with a bachelor of science degree in physics, he invented the first automatic photoelectric timing system for use in timing sports events. He served as an instructor in radio at Haverford College for three years following completion of his course there. From 1934 to 1939, he was a radio engineer with the Philco Corporation in Detroit, Mich. In 1947, Mr. Speakman received the Meritorious Civilian Service Award from the Navy for his work in radar.

Ruiz Receives Yale Engineering Award. The annual award of the Yale Engineering Association for the Advancement of Basic and Applied Science was presented to Albert Louis Ruiz of the General Electric Company. The award was granted for work done by him during the war on bombsight, torpedo-director, and automatic gunfire control projects. Ruiz was graduated from Yale in 1929, and joined General Electric soon after. During the war, he was a member of the National Defense Research Committee of the Office of Scientific Research and Development. Immediately after the war, he served as liaison engineer between General Electric, the Massachusetts Institute of Technology, and the Navy Department, furthering the transfer of a very important classified project to General Electric for final development and production. He is at present in the marine engineering division of the company's aircraft, federal, and marine divisions.

Plastics Society Elects Gooch President. Horace Gooch, Jr., is the new President of The Society of The Plastics Industry, Inc. He will serve for a term of one year. The society, which has a membership of 500 companies and 1,000 individuals in all branches of the plastics industry, is interested in the practical solution of problems concerning standardization, uniform accounting, traffic rates, labor surveys, informative labeling, trade and consumer education, reinforced plastics, buttons, industry conferences, the National Plastics Exposition, and the preparation of technical and consumer literature. Mr. Gooch is Treasurer of Worcester (Mass.) Moulded Plastics Company, of which he is a founder.

Turbogenerators at Sewaren Station

When the Public Service Electric and Gas Company, Newark, N. J., completes construction on its new Sewaren generating station in 1951, it will have four turbogenerator units, with an installed capacity of about 450,000 kw. Two of these units have been delivered so far. The machine shown in the foreground was built by Westinghouse, the other being of General Electric design. These, and a third turbogenerator to be constructed by General Electric, are single-shaft tandem-compound 3,600-rpm units, each with a nominal rating of 100,000 kw. A fourth unit will be similar in design to the other three, but will generate 125,000 kw. It is being built by Westinghouse

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Space Charge Theory Exploded

To the Editor:

In the essay, "Space Charge Theory Exploded," in the January issue (*EE, Jan '49, p 29*) is discussed the space charge effect in a vacuum tube. . . . The space charge itself does not directly exert a force on the electron, but due to the electrons of the space charge the filament assumes a positive charge, and it is actually this positive charge which exerts a force of attraction on the escaping electron. But of course the positive charge would not exist were it not for the space charge. . . .

While many texts and references do not fully describe the physics underlying the space charge effect, the fact remains that the end result of the phenomenon is that the space charge effectively "repels" emitted electrons back to the filament. In this respect the texts and references give explanations which are quite tenable.

ROBERT R. BENNETT

(Student member AIEE, California Institute of Technology, Pasadena, Calif.)

To the Editor:

. . . In Doctor Slepian's recent essay . . . a hollow spherical shell of electric charge will produce zero electric field within it only if there is no electric charge of opposite polarity within the shell. . . . As long as the voltage applied between the anode and filament is high enough, the rate of emission of electrons from the filament never will cause it to become positively charged. . . . If the temperature of the filament is increased further, the filament will become positively charged and those electrons emitted with insufficient velocity will be repelled back to the filament by the electric field set up between the transit electrons and the filament.

SIDNEY SHAPIRO

(Student member AIEE, Electrical Engineering Student, Pratt Institute, Brooklyn, N. Y.)

To the Editor:

Solution of the "Two Electrical Essays" in the January issue are simple, though perhaps not obvious.

Richter's black box contains something which acts as a switch, periodically short-circuiting the box terminals at a frequency too high for a meter to follow. . . .

In Slepian's essay, "Space Charge Theory Exploded," the paradox depends on ignoring . . . the positive charge . . . on the filament. This positive charge will attract the electrons in the space. . . . Although each electron repels all the others, the net force of the repulsion is directed radially outward; and only because of the attractive force exerted by the positive charge on the cathode are the electrons pulled inward.

ROBERT E. McCOY (A '39)

(Consulting Engineer, Portland, Oreg.)

To the Editor:

. . . Doctor Slepian's essay is intriguing. The point is that the conditions assumed in the first paragraphs do not obtain in the application; the fundamental picture in the case of the cylindrical diode has also a positive image charge on the cathode wire to satisfy the boundary conditions, that is, to maintain the given potential difference between cathode and anode. . . .

RICHARD L. GARWIN

(Atomic Energy Commission Fellow in Physics, The University of Chicago, Chicago, Ill.)

To the Editor:

It may seem unfair that I am permitted to reply fully to the commentators on my electrical essays, whereas their letters suffer deletion at the hands of the editor. Adding insult to injury, perhaps, is the fact that I, myself, have assisted the editor in making his deletions. However, the editor has his very difficult problem of keeping *Electrical Engineering* within practical limits of size and budget, so I hope the writers of letters to the editor will forgive him, and me for my connivance with him. I hope that we have satisfied the writers in retaining their important and essential points, even if very briefly and succinctly expressed.

Messrs. Bennett, McCoy, Shapiro, and Garwin correctly bring out that in a space charge limited thermionic tube the charge on the filament must be considered as well as the space charge proper, if the forces acting on an electron in transit are to be calculated correctly from Coulomb repulsion and attraction. With the potential difference between filament and cylindrical anode kept constant, as the filament temperature is raised, the density of space charge increases, it is true, but also at the same time, the charge on the filament changes from negative to positive. If we reckon with Coulomb forces alone, as we may, then it is the attraction of this charge on the filament which draws the electrons back. As stated in the essay, the total force on an electron leaving the filament due to the repulsions or attractions of cylindrical space charge or the charge on the cylindrical anode is strictly zero.

I have to object to Mr. Shapiro's reference to an electric field "set up between the transit electrons and the filament." If the charge on the filament is given, then the field just outside the filament is completely determined in sign and magnitude, and is independent of the magnitudes of the cylindrical space charge of the transit electrons.

I would suggest to Mr. Garwin that the positive charge on the filament cathode be not called an "image" charge. As used in the literature, the image of a point charge, e at a distance r from the axis of a cylinder of radius a, is of magnitude $-e \log r/a$ and is situated at a distance a^2/r from the axis. As Mr. Garwin himself says the charge on the cathode is at its surface, and is determined also by the potential difference between the anode and cathode and not only by the space charge.

I must disagree also with Mr. Bennett that the "texts and references" referred to in my essay, "give explanations which are quite tenable." How can explanations be said to be tenable when they attribute the cause of the effect they are trying to explain to a repulsive effect of the space charge on the electron which admittedly totals up to zero, and make no mention whatsoever of the attraction on the electron by the positive charge on the filament, which Messrs. Bennett, McCoy, Shapiro, and Garwin agree is an essential element of the phenomenon under discussion.

J. SLEPIAN (F '27)

Associate Director, Westinghouse Research Laboratories, East Pittsburgh, Pa.)

PAMPHLETS • • • • •

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

Reports on Infrared Detector and NRCC Progress. One report deals with an infrared detector designed to locate faulty joints in overhead power-line conductors. The other describes progress in the fields of radar electronics, electrical engineering, and radio physics during 1948. "An Infrared Detector for Faulty Joints in Power Lines," PB 95410, can be had for $1.25 in either photostat or microfilm. "NRCC Progress Report, April–June 1948," is available at $6.25 in photostat and $2.50 in microfilm. Order from the Librarian of Congress, Photoduplication Service, Publication Board Project, Washington 25, D. C.

Charts of Compressibility Factors and Charts Showing Quantities Delivered by Commercial Cylinders, for Hydrogen, Nitrogen, and Oxygen. Miscellaneous Publication M191. Charts give number of cubic feet of gas which cylinder will deliver, compressibility factor, and density. Priced at 25 cents. Superintendent of Documents, United States Government Printing Office, Washington 25, D. C.

Army Department Documents. Priced at $1.25 in photostat and in microfilm are the following:

PB 95471, Improvement in Resnatron Tubes; PB 95472, Improved Electronic Voltage Regulator; PB 95473, Improved Means for Measuring Gain of Amplifiers; PB 95474, Improved Electronic Voltage Regulator; PB 95475, An Improved Wide-Band UHF Amplifier; PB 95444, Improvement in Resonance Characteristics of Power Supply Leads for UHF Vacuum Tubes;

PB 95446, Extension of Dry Battery Cell Life Through Improvement in Electrolyte-Absorbent Element; PB 95447, Improvement in Method of Obtaining Circular Polarization in Wave Guides of Circular Cross Section; PB 95449, Improved Electrical Connectors; PB 95453, Moisture-proofed Compounds for Crystal Holders; PB 95454, Improvement in Transfer of Radio Frequency Energy Between Coaxial Lines and Wave Guides; PB 95459, Coaxial Transmission Line Having Low Attenuation and Low Standing Wave Ratio; PB 95461, An Improved Multivibrator; PB 95462, An Improved Tow-Line Coupler; PB 95463, A Shock and Vibration Resistant Connector; PB 95464, Improvement in Low-Pass RF Filters; PB 95465, An Improved Stub Antenna Mounting Plate; PB 95469, Improved Modulation Control of Reflex Klystron Tubes; PB 95467, Improved Remote Controlled (Radio) Device.

Selling for $2.50 in photostat and $1.75 in microfilm are

PB 95466, Improved High-Speed Automatic Keyer for Radio Transmitters; PB 95468, Improved Shielding for Cathode-Ray Tubes.

Remit orders to Librarian of Congress, Photoduplication Service, Washington 25, D. C.

Aerodynamics of the Wind Turbine. Giving an account of air actions in the operating turbine, this booklet suggests use of the wind as an auxiliary source of power for utilities. Third in a series of monographs on wind power, its predecessor volumes are "The Wind Power Aerogenerator" and "Electric Power From the Wind." Copies of any of the three volumes may be obtained by writing to the Federal Power Commission, Washington 25, D. C.

Determination of Factors Affecting Lamination in Structural Clay Products. Bulletin 164. Contains an evaluation of the plasticity of clay samples taken from an area bordering on the state of Iowa. Available from the Iowa Engineering Experiment Station, Iowa State College, Ames, Iowa.

How to Treat a Gage. Maintenance, protection from dirt, and storage are discussed. The 4-page leaflet may be obtained at ten cents per copy from V. W. Palen, Bureau of Public Information, New York University, Washington Square, New York 3, N. Y.

Two Recommended-Practices Leaflets. "Coding of Thermocouple Wire and Extension Wire," RP1.1, gives symbols for standard thermocouple combinations. Priced at $1. "Manometer Tables," RP2.1, presents abbreviations, conversion factors, and definitions of pressure in terms of mercury and water at various temperatures. Sells for $2. Both standards are available from the Instrument Society of America, 1117 Wolfendale Street, Pittsburgh 12, Pa.

Time and Motion Study Sound Film. Loaned free of charge to any employing group. For further information, contact Lyne S. Metcalf, 51 East 42d Street, New York 17, N. Y.

Calculating Coupling Gears, PB 96256. Develops theoretical basis for calculating elements based on coupling gears. 183 pages. Available at $23.75 in photostat, $6.75 in microfilm. Address orders to Librarian of Congress, Photoduplication Service, Publication Board Project, Washington 25, D. C.

NEW BOOKS

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

DESIGN OF CRYSTAL VIBRATING SYSTEMS FOR PROJECTORS AND OTHER APPLICATIONS. By W. J. Fry, J. M. Taylor, and B. W. Henvis. Dover Publications, New York, N. Y., 1948. 182 pages, diagrams, charts, tables, 9½ by 6 inches, cloth, $3.50. A detailed study is presented of crystal vibrating systems and procedures for their design involving graphs based on fundamental piezoelectric relations. Part 1 contains the design curves and detailed explanations of their use. Part 2 deals with the mathematical analysis and the derivations of the expressions used in constructing the curves. Appendixes A and B provide units, definitions, symbols, conventions, and tables and graphs of physical constants.

ELECTRIC GENERATORS, OPERATION AND MAINTENANCE. By E. J. Kates and H. E. Stafford. American Technical Society, Chicago, Ill., 1948. 268 pages, illustrations, diagrams, charts, tables, 8½ by 5½ inches, cloth, $2.75. The purpose of this book is to supply the information needed to decrease breakdowns, save time in analyzing difficulties, and aid in making speedy repairs to electric generators and motors. It is assumed that the reader understands the basic principles by which an electrical generator operates. Considerable explanation is given to voltage regulation, and the parallel operation of generators is treated in a practical manner.

ENGINEERING THERMODYNAMICS. By J. S. Doolittle and A. H. Zerban. International Textbook Company, Scranton, Pa., 1948. 429 pages, illustrations, diagrams, charts, tables, 9¼ by 6 inches, cloth, $5. Intended as a text for a year's course in thermodynamics, this book stresses fundamentals of the science, with brief applications to the art of heat-power engineering. The basis of this work is to present as few equations as possible and then to show how problems may be analyzed and solved by the application of a few fundamental principles.

EXPLORING ELECTRICITY, MAN'S UNFINISHED QUEST. By H. H. Skilling. Ronald Press Company, New York, N. Y., 1948. 277 pages, illustrations, diagrams, 8¼ by 5½ inches, cloth, $3.50. Considering electricity through the years as the scientist knew it, this volume is devoted to stories of these scientists and their friends, including the outstanding personalities from Thales to Fermi. A knowledge of electrical principles is developed through the historical approach.

GEOGRAPHICAL DISTRIBUTION OF ENGINEERING RESEARCH AND RELATED INDUSTRIES IN THE UNITED STATES. (Technical Publication 481). By H. M. Conway, Jr. Southeastern Research Institute, 5009 Peachtree Road, Atlanta, Ga., January, 1948. No pagination, diagrs., charts, maps, tables, 11 by 8½ inches, paper, $2. Surveying the research establishments of the nation, this volume affords a basis of comparison of engineering research and development activity in various sections of the country. It appraises the present distribution of activity, analyzes the causes, and suggests means by which undesirable conditions can be minimized in the future.

LITERATURE SEARCH ON DRY CELL TECHNOLOGY (Special Report 27). By M. Bolen and B. H. Weil. Georgia Institute of Technology, State Engineering Experiment Station, Atlanta, Ga., 1948. 700 pages, 8½ by 5½ inches, leather, $5.; foreign, $5.50. This compilation, placing special emphasis on synthetic manganese dioxide depolarizers, was prepared in connection with a research program at the State Engineering Experiment Station of the Georgia Institute of Technology. It constitutes an indexed, annotated bibliography of the pertinent literature dealing with dry cell technology, manganese ore deposits throughout the world, and methods of treating such ores for the preparation of depolarizing compounds.

MATHEMATICAL SOLUTION OF ENGINEERING PROBLEMS. By M. G. Salvadori with a collection of problems by K. S. Miller. McGraw-Hill Book Company, New York, N. Y., Toronto, Ontario, Canada, London, England, 1948. 245 pages, diagrams, charts, tables, 9¼ by 6 inches, cloth, $3.50. This book aims at widening the mathematical background of the student and at filling the gap between theoretical mathematics and the technique of solving physical problems. The six chapters deal with: fundamental ideas of mathematics, use of plane Cartesian geometry, solution of algebraic and transcendental equations, solution of systems of simultaneous linear equations, elementary functions of a real and complex variable, and the Fourier series.

QUALITY CONTROL METHODS. By C. W. Kennedy. Prentice-Hall, New York, N. Y., 1948. 243 pages, illustrations, diagrams, charts, tables, 9¼ by 6 inches, cloth, $4.75. This book supplies the necessary elementary information needed to understand the more technical and involved practices that modern quality control requires. A combination of the theoretical and practical, acceptance sampling, batch control, distributions and the standard deviation, average and range, and administrative methods are considered.

RADIO ENGINEERING, Volume I. By E. K. Sandeman. John Wiley and Sons, New York, N. Y., 1948. 775 pages, diagrams, charts, tables, 9 by 5½ inches, cloth, $6.50. Originally planned as instructions for maintenance engineers at British Broadcasting Company transmitting stations, this book gives to beginners in radio the working principles they need, and is also a reference volume for experienced radio engineers and designers. A working knowledge of elementary algebra and logarithms is needed.

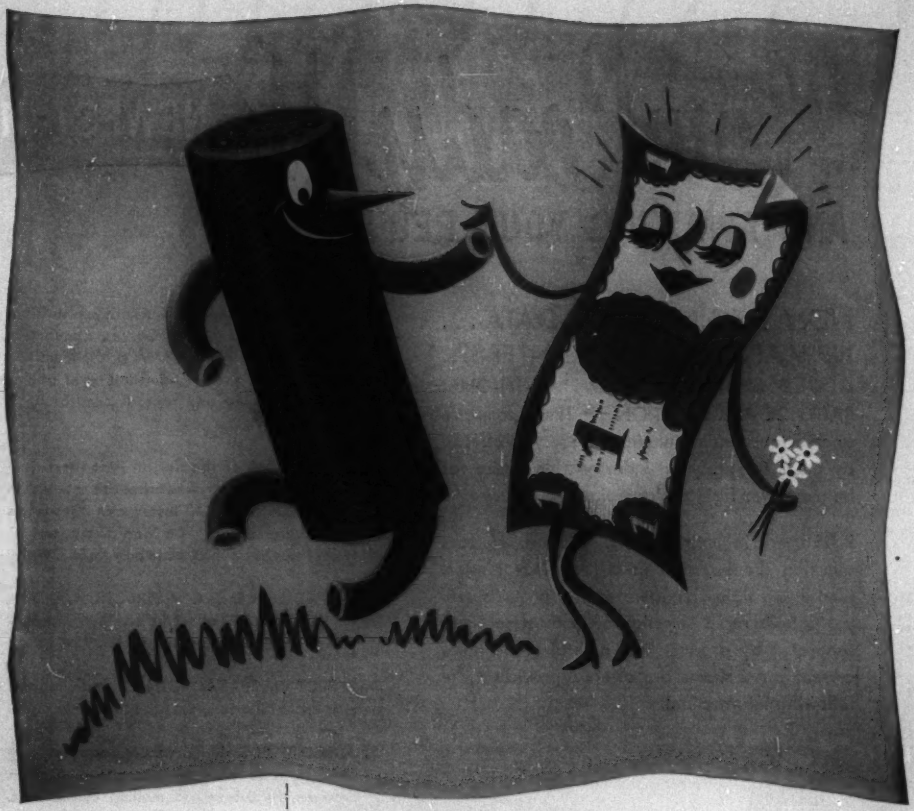
PROCESS ENGINEERING. By W. H. Schutt, McGraw-Hill Book Company, New York, N. Y. Toronto, Ontario, Canada; London, England, 1948. 309 pages, diagrams, charts, tables, 9¼ by 6 inches, cloth, $4. Process engineering is considered as the phase of industrial engineering which determines the means, methods, and procedure of manufacturing an article economically. Detailed information is given on material selection, speed and feed formulas, the manual processes for all kinds of machining operations, estimating the size of blanks, and other items necessary for determining the direct-labor cost of an article to be manufactured. Specific cases of power-press work, machining and assembling operations are carried through in detail to the final cost estimation.

PROPRIÉTÉS ÉLECTRIQUES DES RÉSINES SYNTHÉTIQUES. By J. Granier and G. Granier. Dunod, Paris, France, 1948. 180 pages, diagrams charts, tables, 8½ by 5½ inches, paper, 680 frs. An account of recent work on the properties of each type of synthetic resin. The first part is devoted to data of industrial importance: general properties of synthetic resins, composition and electrical properties, and utilization of plastics in the electrical industries. Part 2 is devoted to theoretical aspects: dielectric polarization, distribution of relaxation times, influence of viscosity, and electric moments of high polymers.

SOCIETY FOR EXPERIMENTAL STRESS ANALYSIS, PROCEEDINGS, volume 5, number 2. Edited by C. Lipson and W. M. Murray. Published and distributed by Addison-Wesley Press, Inc., Kendall Square, Cambridge 42, Mass., 1948. 153 pages, illustrations, diagrams, charts, tables, 11 by 8½ inches, cloth, $6. The 16 papers presented in this volume cover various aspects of stress and strain analysis chiefly by strain-gauge and photoelastic methods. Special topics dealt with are: a pendulum analyzer for mechanical transients; photo-grid process for measuring strain in underwater explosions; the selection of allowable stresses for steel members; investigation of buckling shock mount.

Library Services

ENGINEERING Societies Library books may be borrowed by mail by AIEE members for a small handling charge. The library also prepares bibliographies, maintains search and photostat services, and can provide microfilm copies of any item in its collection. Address inquiries to Ralph H. Phelps, Director, Engineering Societies Library, 29 West 39th St., New York 18, N. Y.



How to lift a dollar's morale...

If there's anything that makes a man feel "down in the dumps" it's the thought that he's not as good as he used to be. So it's easy to imagine what a dollar must feel like when it reflects on the good old days.

There are billions of dollars floating around today . . . but what with inflation and all, they aren't happy.

When it comes to buying cable, however, you can step up the morale of your dollars, because there's nothing that will give a cable dollar a lift like being invested in Kerite.

Makes a dollar go farther . . . last longer . . . buy more years of service . . . than if it were to go for something less permanent.

Why, we know of Kerite cable that's been in service for more than fifty years and is still going strong! And you'll be glad to know the Kerite that makes that cable endure is the same Kerite used in making present-day Kerite insulation.

We have interviewed several dollars lately. They tell us that it's a real relief to be clearing through our bank. Makes them feel important to buy cable with such long life and such low cost per year. The Kerite Co., 30 Church St., New York 7.

Kerite Insulation—Your Cable's Best Life Insurance

KERITE CABLE

Now Ready!

NEWEST TIME

AND AWAITING YOUR REQUEST...

NEW ENGINEERING DATA... NEW APPLICATION "POINTERS"...

ADDED SPEEDS . . . NEW "ALL-IN-ONE" PACKAGE PRESENTATION — These comprise another outstanding engineering service offered by S&C to satisfy an industry-wide desire for better power fusing information.

Packaged in convenient, indexed, folders punched for insertion in a loose-leaf binder, filed in a visible arrangement that protects and yet permits rapid selection of each sheet, and separated by product line, a total of 58 time-current curve sheets are offered providing the following information:

1. NEW TOTAL-CLEARING, Minimum-Melting, and Short-Time Rating Curves, accurately drawn on fine scale NEMA grids, identified by color, and printed on transparent paper, ideal for tracing and reproduction, or light-table comparisons.

2. REFUTATION of the notion that short-time curves or "set-back" allowances are essential in the coordination of *all* fuses—such allowances being unnecessary with "non-damageable" fusible elements, obtainable only in S&C fuses.

3. FUSIBLE ELEMENT CONSTRUCTION DESIGNATED, with its effect upon "non-damageability" and accuracy stated.

4. EFFECT OF "PRE-LOADING", and ambient temperature variations.

5. ADDED SPEEDS—Standard, Slow and Time-Lag Characteristics with average speed ratios—between the 0.1-second melting current and the 300-second melting current—of 7 to 1, 10 to 1 and 13 to 1, respectively.

6. HIGHER AMPERE RATINGS.

For your *free* Time-Current Characteristic Folders pictured on the opposite page please write, on your business letterhead, TODAY!!!

The growing need for, and increasing importance of, this more detailed, more accurate, fuse coordination data was created by the

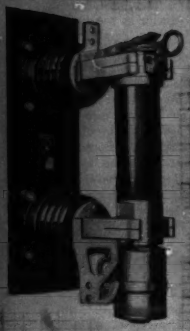
NEW CONCEPT OF PRIMARY FUSING

namely, *Full Coverage,* in which a primary fuse is applied for *both* primary short circuit and secondary backup short circuit protection.

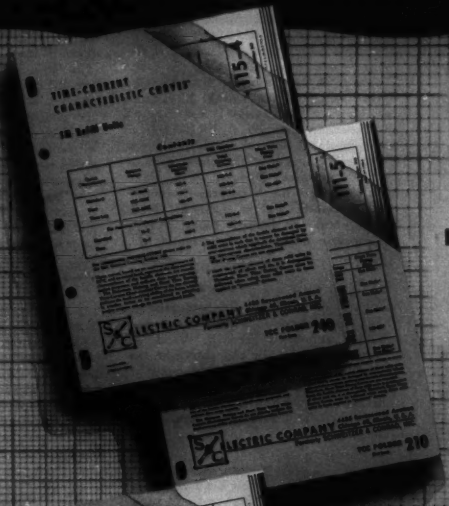
This practice requires a "non-damageable" fusible element, dependable low-fault-current interrupting ability, ability to function dependably under conditions of severe recovery voltage, and a fine degree of accuracy in time-current characteristics—a combination of qualities found only in S & C fuses.

S&C ELECTRIC

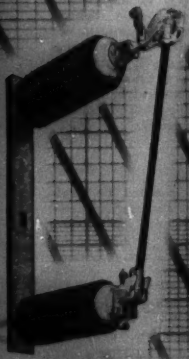
CURRENT INFORMATION FOR POWER FUSING



SM POWER FUSE
(Boric Acid—Heavy Duty)
RATINGS
Volts: 7500 to 34,500
Amperes: ½ to 800E



LIQUID POWER FUSE
RATINGS
Volts: 7500 to 138,000
Amperes: ½ to 250E



HSO POWER FUSE
(Boric Acid—Drop-Out)
RATINGS
Volts: 7500 to 69,000
Amperes: 1 to 200E

SMD-2 POWER FUSE
(Boric Acid-Heavy Duty-Drop-Out)
RATINGS
Volts: 34,500 to 138,000
Amperes: 1 to 300E

COMPANY 6627 Kenwood Avenue
Chicago 49, Illinois, U. S. A.
Formerly S. SCHWEITZER & CONRAD, INC.

Silicone News

DC

Silicone Insulation Gives Rapidly Reversing Motor 10 Times Normal Life

That's significant news to designers of machine tools. Even more significant perhaps to electrical engineers is the further confirmation of our laboratory and motor test results. These tests indicated that Silicone Insulation has 10 times the life and 10 times the wet insulation resistance of Class 'B' insulation under comparable conditions.

PHOTO COURTESY COGSDILL TWIST DRILL COMPANY

Improved drill grinder depends upon DC Silicone Insulation for long trouble-free operation.

Engineers at Cogsdill Twist Drill Company of Detroit developed a unique machine for grinding drills. Instead of reversing the carriage by a conventional cam or crank, they use a 1 h.p., 1200 r.p.m. motor to reverse the carriage drive 50-60 times per minute.

In this service, Class 'A' insulated motors lasted 3 to 4 days; Class 'B' insulated motors lasted 3 to 5 weeks. After repeated failures, the reversing motors were rewound with DC Silicone Insulation by the A. H. Nimmo Electric Company of Detroit.

The motor bearings were packed with DC 44 Silicone Grease and the frame was painted with DC Silicone enamel. The motors have now been in service over 10 months and show no sign of failure. A hazardous smoke problem caused by the burning of conventional finishes also has been eliminated.

This is a typical example of how Dow Corning Silicone Insulation increases the life and reliability of hard working motors. Specifications for rewinding ac motors are given in sheet G6A8.

DOW CORNING CORPORATION
MIDLAND, MICHIGAN
Atlanta • Chicago • Cleveland • Dallas
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In Canada: Fiberglas Canada, Ltd., Toronto
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Dow Corning
FIRST IN SILICONES

INDUSTRIAL NOTES ....

I. G. E. Appointments. The International General Electric Company has made the following appointments: Bruce M. Robertson has been elected Treasurer; Felix Dayton has been made assistant on corporate affairs of the company's Executive Department; Henry C. Maher has been appointed administrative assistant; Lawrence Wenz has been made Assistant Treasurer of the company; Karl Philippi has been made Manager of the Electronics and Merchandise Division; and Edward H. Sheahan, commercial Vice-President of International General Electric, has been appointed Manager of the newly consolidated Apparatus Division. The three main sections of the Apparatus Division—the Schnectady Section, Domestic Sales Section, and the Foreign Sales Section, now operate under the direction of Mr. Sheahan.

New A. B. Chance Representatives. The A. B. Chance Company, Centralia, Mo., has appointed Fred. B. Woods as sales representative in the southeast, to work with W. A. Moss, Sales Manager of that division, and E. J. Higgins, sales engineer, will work with C. T. Nevins, the company's Eastern Division Sales Manager.

General Cable Opens New Branch Office. The General Cable Corporation, with headquarters in New York City, has opened a new branch office at 60 Park Place, Newark 2, N. J. The staff includes C. M. Sherwood, Manager, W. T. Wessels, sales engineer, C. E. Thomas, John Cheetham, and Piet Pieters, salesman.

Westinghouse News. At the Westinghouse Electric Corporation's Atomic Power Division, Neil D. Cole has been appointed Contract Supervisor; Charles J. Gerhart has been named Security Officer; Charles F. Stewart has been made Industrial Relations Supervisor; and C. H. Doran has been appointed Supervisor of Receiving, Store, and Shipping. At the company's Appliance Division plant in East Springfield, Mass., Milton Kalischer has been named Manager of the Engineering Department, and Graham S. McCloy has been appointed to succeed Mr. Kalischer, as Manager of the Engineering Department's Technical Development Section.

C. A. Staub Treasurer of Cornell-Dubilier. C. A. Staub, formerly Assistant Secretary and Comptroller of Radiart Corporation, Cleveland, Ohio, which is now a subsidiary of Cornell-Dubilier, has been appointed Treasurer of the Cornell-Dubilier Electric Corporation, at South Plainfield, N. J.

General Electric Appointment. Charles G. Roberts has been named Television Equipment Product Manager for General Electric's Transmitter Division at Electronics Park, Syracuse, N. Y.

Tin Research Institute Formed. John Ireland, director, Tin Research Institute, London, England, has announced the formation of an American corporation, Tin Research Institute, Inc., which will provide free technical service to consumers of tin in the United States. The office of the new corporation, at 492 West Sixth Avenue, Columbus 1, Ohio, will handle all requests for technical service, while a sponsorship will be maintained at Battelle Memorial Institute to handle new researches. Robert J. Nekervis, appointed Supervisor of Metallurgical Development, and Robert M. MacIntosh, named Supervisor of Chemical Development, have both been associated with Battelle Memorial Institute for the past eight years.

American Steel and Wire Company Appointments. Harry H. Lumley, formerly Chicago District Manager of operations for the American Steel and Wire Company, a subsidiary of United States Steel, has been appointed assistant to the Vice-President of Operations. John R. Gaut will succeed Mr. Lumley in his former position.

Sylvania Forms Canadian Subsidiary. Sylvania Electric Products, Inc., has formed a Canadian subsidiary, to manufacture fluorescent lamps and other lighting equipment. The new company, known as Sylvania Electric (Canada) Ltd., has leased a plant from the city of Drummondville in the Province of Quebec. F. J. Healy has become President of the new company; R. H. Bishop, Vice-President; William O'Keefe, Secretary; and M. F. Balcom, Treasurer.

Dr. Benedict Joins Stanford Research Staff. Dr. Donald L. Benedict, formerly a research fellow in electronics at Harvard University's Department of Engineering Science and Applied Physics, has been appointed Assistant Chairman of the Department of Electrical Engineering of Stanford Research Institute, Stanford, Calif.

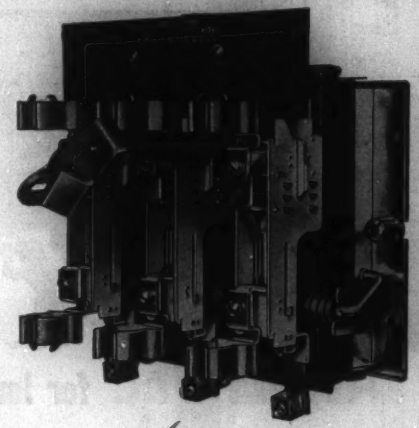
Capehart-Farnsworth Elections. Capehart-Farnsworth Corporation, newly formed subsidiary of the International Telephone and Telegraph Corporation, recently elected Ellery W. Stone as President, David R. Hull, Executive Vice-President; Philo T. Farnsworth, Henry C. Roemer, and William Clausen, Vice-Presidents; P. H. Hartmann, Treasurer, W. F. Hoeppner, Comptroller; Chester H. Wiggin, Secretary and Assistant Treasurer; Dudley M. Day, and C. Douglas Webb, Assistant Secretaries; John J.

(*Continued on page 20A*)

NOW...an ALL-NEW Type A Safety Switch for modern high-capacity distribution systems...

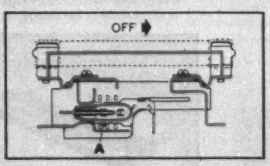
TRUMBULL'S HCI

HIGH CAPACITY INTERRUPTER

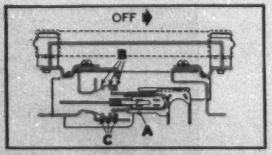


Unusually high interrupting capacity..."circuit-breaker" action breaks heavy loads quickly, safely. Extremely high momentary current capacity... withstands heavy short circuits without damage. 30-, 60-, 100-ampere sizes.

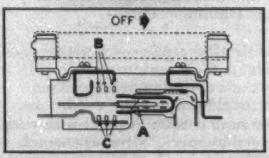
Here's How...
HCI's "Circuit-Breaker" Action Works



1. Switch closed. Spring-loaded sliding contact (A) fully inserted between stationary contacts. Red indicates current.



2. Sliding contact being withdrawn. The two arcs repel each other, are drawn against grid pins (B) and (C), which break and cool them.



3. Contact fully withdrawn. Trumbull's unique "Circuit-Breaker" action has effectively extinguished the arcs.

CHECK THESE ADDITIONAL SPACE-SAVING, TROUBLE-PREVENTING, LIFE-LENGTHENING FEATURES

Center-front operation permits close ganging.

Front fusing allows compact box, yet gives ample wiring space.

No exposed live parts when switch is OFF and door is open.

Handle interlock.

Clear ON and OFF markings both inside and outside.

No dead center—roller-cam action (multiplying linkage design with powerful spring) throws switch to full OFF and ON.

Poles are self-contained switching units for easy replacement.

Silver-plated current-carrying parts prevent oxidation . . . give low-resistance contact.

Insulating parts made of linen melamene, light, strong, arc-resisting.

Enclosed operating mechanism (on 60- and 100-amp. sizes) prevents wire chafing.

Interior removable for wiring ease.

Underwriters' approval throughout.

For more information about Trumbull's all-new HCI Safety Switch, write for your free copy of Bulletin TEC-10 today. THE TRUMBULL ELECTRIC MANUFACTURING COMPANY, Plainville, Connecticut.

Men Who Observe the Best Electrical Practice Make It a Practice to Use

TRUMBULL (T) ELECTRIC

TRUMBULL'S TRAINLOAD OF NEW PRODUCTS

AVAILABLE for Immediate Delivery

From a Stock of Several Million

RHEOSTATS • RESISTORS • TAP SWITCHES

WHEN your purchasing orders for resistance units are stamped "Rush" . . . *wire Ohmite.* Chances are the exact unit you need can be shipped immediately from Ohmite stock—believed to be the largest supply of power rheostats, wire-wound resistors, and rotary tap switches in the world. Actually several million units—in 1859 types, sizes, and values—are ready for delivery. All, of course, of typically high Ohmite quality—*Industry's First Choice.*

Ohmite rheostats are characterized by their all-ceramic construction . . . their smoothly gliding metal-graphite brush . . . their uniform windings locked in place by vitreous enamel . . . and their ability to provide close control and trouble-free service under the toughest operating conditions.

Ohmite resistors are built on a strong ceramic core . . . wound with even windings that prevent "hot spots" . . . protected by special vitreous enamel. Terminal lugs are tin-dipped for easy soldering.

Ohmite tap switches are unsurpassed in combining high current capacity . . . large number of taps . . . compactness. They have one-piece ceramic bodies unaffected by arcing . . . "slow-break, quick-make" action proved best for a-c use.

Why not let Ohmite serve you when you need resistance units *fast?*

Write on company letterhead for your copy of the Ohmite Catalog and Engineering Manual No. 40

OHMITE MANUFACTURING CO., 4801 Flournoy St., Chicago 44

Be Right with- OHMITE

RHEOSTATS—Six stock sizes. Others to order. 25 to 1000 watts.

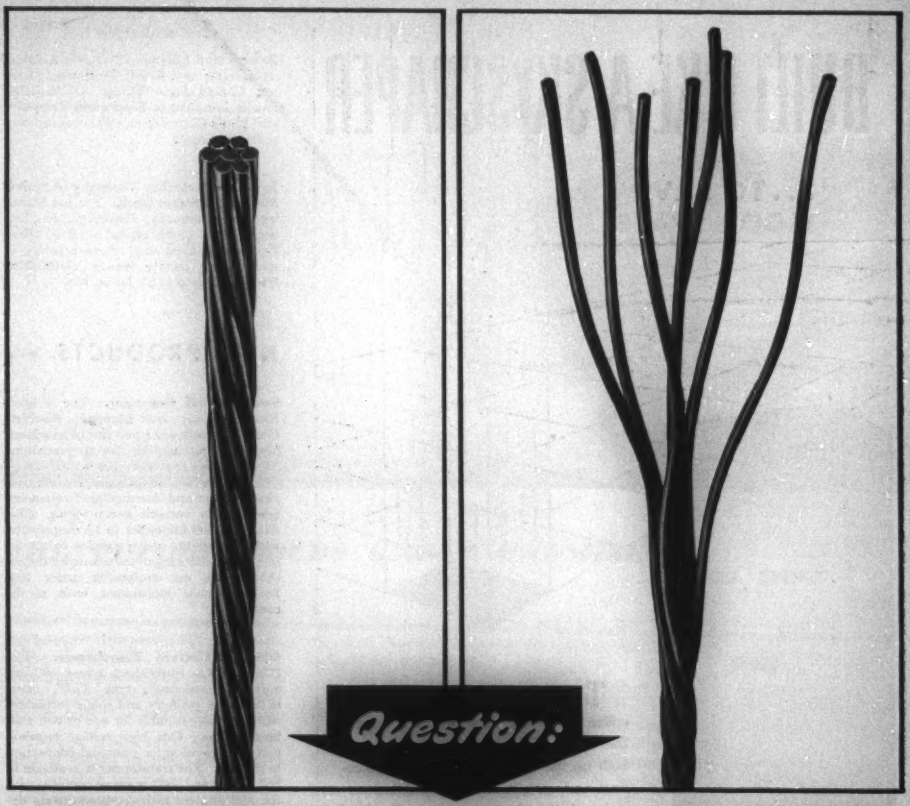
FIXED RESISTORS—Five sizes, 25 to 200 watts, 1 to 250,000 ohms.

DIVIDOHM RESISTORS—Adjustable resistances. 10 to 200 watts.

THIN TYPE RESISTORS—Made to order only—five wattage sizes.

BROWN DEVILS—Vitreous-enameled resistors. 5, 10, and 20 watts.

TAP SWITCHES—Five sizes from 10 to 100 amps. 2 to 12 taps.



WHICH WOULD YOU RATHER WORK WITH?

The Form-Set strand on the left—with every wire smoothly in place? Or the strand at the right, whose wires spray out in every direction when the seizing is removed?

The answer, at least in part, can be gained from the pictures. Bethlehem's Form-Set strand is preformed; that is, each individual wire is preshaped before being laid together with its neighbors. The wires have no tense, inner urge to spring apart. Hence, when cut, the strand doesn't "unravel"; it keeps its original shape and compactness, even without seizing.

This means easier handling, faster work in the field. It means Form-Set is easier to insert in fittings. Linemen vouch for this preformed strand, because it enables them to work more swiftly and surely.

Something the pictures *don't* show is the low cost of Form-Set. The slight extra charge for preforming is so small as to be negligible. Its added advantages, therefore, cost you almost nothing.

All Form-Set strand has the ductile bethanized coating—a guardian zinc armor applied by Bethlehem's exclusive process. It is available in A, B, and C weights to meet atmospheric conditions in any given area. Ask a Bethlehem man for full details.

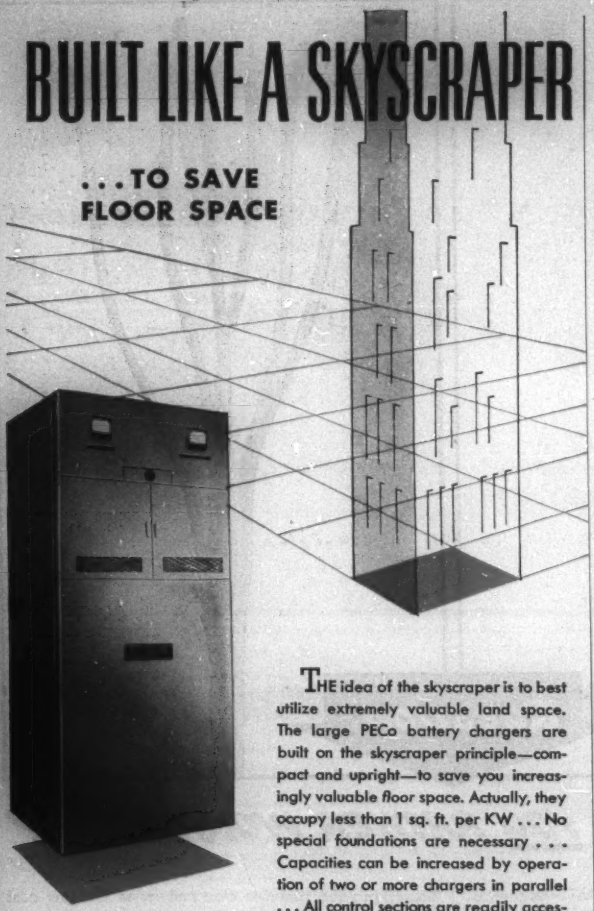
BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.
On the Pacific Coast Bethlehem products are sold by
Bethlehem Pacific Coast Steel Corporation
Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

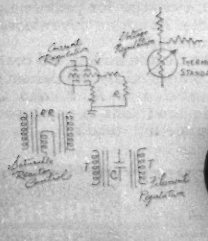
Bethlehem FORM-SET Strand

BUILT LIKE A SKYSCRAPER

. . . TO SAVE FLOOR SPACE



THE idea of the skyscraper is to best utilize extremely valuable land space. The large PECo battery chargers are built on the skyscraper principle—compact and upright—to save you increasingly valuable floor space. Actually, they occupy less than 1 sq. ft. per KW . . . No special foundations are necessary . . . Capacities can be increased by operation of two or more chargers in parallel . . . All control sections are readily accessible. Rectifier assemblies are on removable trays to facilitate inspection or service . . . Fully automatic; electronically or magnetically controlled and regulated; accurate floating voltage control within ±1% . . . Complete range of sizes up to 10 KW . . . Write for all the facts.



POWER EQUIPMENT *Company*

Specialists in Controlled Rectifiers Since 1935

55 ANTOINETTE STREET / DETROIT 2, MICHIGAN

(Continued from page 16A)

Brosnan and Edmond H. Dufau, Assistant Treasurers; and Roy H. Workman, Assistant Comptroller. Edwin A. Nicholas, former President of Farnsworth Television and Radio Corporation, will act as assistant to the President.

Joy Manufacturing Company Acquires Mines Equipment Stock. The Joy Manufacturing Company, Pittsburgh, Pa., has acquired all of the capital stock of Mines Equipment Company, manufacturers of mines and factory power distribution systems, located in St. Louis, Mo.

NEW PRODUCTS . .

Sweep Signal Generator. The Triplett Electrical Instrument Company, Bluffton, Ohio, has produced a new line of television-frequency modulation sweep generators. Model *3435* provides continuous range coverage to 240 megacycles for all television carrier and intermediate frequencies, continuously variable sweep width, effective from 500 kilocycles to 12 megacycles, with off position, and a standby switch for temporary silencing of the generator during other work on equipment under test. For additional information, write to the company.

600-Volt Current Transformer. Allis-Chalmers has introduced a new 600-volt current transformer, type *KLW*, made with single primary and single secondary with accuracy suitable for one or two watt hour meters. One high voltage terminal pad has provision for potential connection to meters. The transformer is available in 200, 400, and 600 ampere ratings with the 400 ampere rating conservatively designed to operate continuously at 150 per cent rated current and the 200 and 600 ampere ratings for continuous service at 200 per cent rated capacity. Further information may be obtained from the Allis-Chalmers Manufacturing Company, 931 South 70th Street, Milwaukee, Wis.

Portable Voltage Regulating Instrument. The Acme Electric Corporation, Cuba, N. Y., has developed a new low priced Voltrol, intended for use in testing electrical and electronic components and finished products on voltage ranges between 70 and 130 volts. Basically a specially constructed transformer, the Voltrol regulation is accurate to 4/10 volt adjustment, and the output voltage is practically independent of the load. Further information is available from the company.

Transmitter Mica Capacitors With Universal Mounting. The Cornell-Dubilier Electric Corporation, South Plainfield, N. J., is now manufacturing a new line of transmitter mica capacitors with universal

(Continued on page 28A)

THE FUTURE HOLDS GREAT PROMISE

Neither chance nor mere good fortune has brought this nation the finest telephone service in the world. The service Americans enjoy in such abundance is directly the product of their own imagination, enterprise and common sense.

The people of America have put billions of dollars of their savings into building their telephone system. They have learned more and more ways to use the telephone to advantage, and have continuously encouraged invention and initiative to find new paths toward new horizons.

They have made the rendering of telephone service a public trust; at the same time, they have given the telephone companies, under regulation, the freedom and resources they must have to do their job as well as possible.

In this climate of freedom and responsibility, the Bell System has provided service of steadily increasing value to more and more people. Our policy, often stated, is to give the best possible service at the lowest cost consistent with financial safety and fair treatment of employees. We are organized as we are in order to carry that policy out.

Bell Telephone Laboratories lead the world in improving communication devices and techniques.

Western Electric Company provides the Bell operating companies with telephone equipment of the highest quality at reasonable prices, and can always be counted on in emergencies to deliver the goods whenever and wherever needed.

The operating telephone companies and the parent company work together so that improvements in one place may spread quickly to others. Because all units of the System have the same service goals, great benefits flow to the public.

Similarly, the financial good health of the Bell System over a period of many years has been to the advantage of the public no less than the stockholders and employees.

It is equally essential and in the public interest that telephone rates and earnings now and in the future be adequate to continue to pay good wages, protect the billions of dollars of savings invested in the System, and attract the new capital needed to meet the service opportunities and responsibilities ahead.

There is a tremendous amount of work to be done in the near future and the System's technical and human resources to do it have never been better. Our physical equipment is the best in history, though still heavily loaded, and we have many new and improved facilities to incorporate in the plant. Employees are competent and courteous. The long-standing Bell System policy of making promotions from the ranks assures the continuing vigor of the organization.

With these assets, with the traditional spirit of service to get the message through, and with confidence that the American people understand the need for maintaining on a sound financial basis the essential public services performed by the Bell System, we look forward to providing a service better and more valuable in the future than at any time in the past. We pledge our utmost efforts to that end.

LEROY A. WILSON, *President*
American Telephone and Telegraph Company.
(From the 1948 Annual Report.)

BELL TELEPHONE LABORATORIES EXPLORING AND INVENTING, DEVISING AND PERFECTING, FOR CONTINUED IMPROVEMENTS AND ECONOMIES IN TELEPHONE SERVICE

Allis-Chalmers Reports To Electric Utilities On . . .

MODERN SWITCHGEAR

Advanced Construction Methods and Up-to-date Manufacturing Facilities Insure Highest Quality Switchgear

IF YOU WERE to take a step-by-step tour of Allis-Chalmers modern switchgear plant, you would see today's most advanced construction methods in use. In one of the first operations, for example, you would see panels being accurately punched on giant 32-station presses . . . and framework welded in huge precision jigs to insure true alignment.

Panels and framework are then conveyed through a series of spray tunnels, where they are subjected to de-greasing, cleaning, chemical treating and sealing solutions. Next they are given necessary primary and finish coats of paint, and dried in infra-red baking tunnels.

The painted structures are moved to the assembly floor where they are assembled in groups on their own sill channels, and bolted to permanently leveled erection plates. This assures accurate alignment of the units for easy installation in the field.

Units are now ready for wiring and installation of breakers, meters, etc. Those parts requiring silver plating are processed in A-C's own plating department.

After assembly is completed, units undergo final inspection and are tested under simulated operating conditions, receive their final coat of paint, and are prepared and loaded for shipment.

Advanced construction methods like these help to make Allis-Chalmers switchgear dependable in performance and low in maintenance cost. Ask your nearby A-C sales representative to call and discuss other details of Allis-Chalmers switchgear, including recent improvements in design. Or write direct.

ALLIS-CHALMERS, 931A SO. 70 ST.
MILWAUKEE, WIS.

A 2663

IN 1926 — Allis-Chalmers introduced Metal-Clad Switchgear into America, outmoding open type, piecemeal switching centers.

TODAY — A-C offers a range of switchgear, switchboards and unit substations to meet practically any utility or industrial need.

ALLIS-

Pioneers in Power and

METHODS

Production is speeded with 32-station presses which punch panels accurately in an infinite variety of die shapes.

Framework is constructed of steel angles and formed plates, welded together in full size jigs. Where welded joints are made, angles are offset for maximum strength.

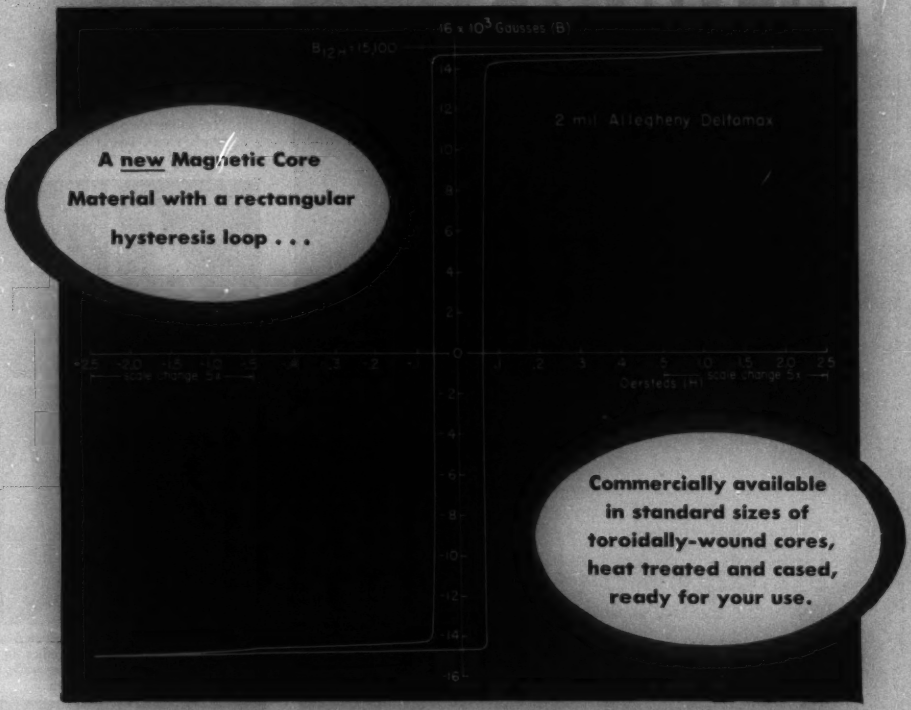
Parts requiring silver plating are processed in A-C's own fully equipped plating department.

CHALMERS

Electrical Equipment From Generation Through Utilization

A-C ALLIS-CHALMERS

DELTAMAX—*now available!*


A new Magnetic Core Material with a rectangular hysteresis loop . . .
2 mil Allegheny Deltamax
Commercially available in standard sizes of toroidally-wound cores, heat treated and cased, ready for your use.

Where can YOU use a Magnetic Material with these specialized, dependable characteristics?

The properties of Deltamax are invaluable for many electronic applications, such as new and improved types of mechanical rectifiers, magnetic amplifiers, saturable reactors, peaking transformers, etc. This new magnetic material is available now as "packaged" units (cased cores ready for winding and final assembly) distributed by the Arnold organization. Every step in manufacture has been fully developed; designers can rely on complete consistency in each standard size of core.

Deltamax is the most recent extension of the family of special, high-quality electrical materials produced by Allegheny Ludlum, steel-makers to the electrical industry. It is an orientated 50% nickel-iron alloy, characterized by a rectangular hysteresis loop with sharply defined knees, combining high saturation with low coercivity.

● *Call on us for technical data.*

THE ARNOLD ENGINEERING COMPANY

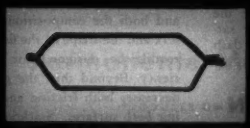
SUBSIDIARY OF ALLEGHENY LUDLUM STEEL CORPORATION

147 EAST ONTARIO STREET, CHICAGO 11, ILLINOIS

these National Coils have been

"RAILROADED"

Field Coils (full AIEE Class H insulation) — which remain tight in the frame because they efficiently dissipate heat, withstand high temperatures and are pre-seasoned.



Armature Coils (full AIEE Class H insulation) — hotpressed, all Silicone mica and glass insulated, for especially long, especially dependable service.

AND THEY'RE STILL GOING!

Typical of the exceptional dependability of National Silicone Mica-Glas field coils and armatures is the experience of one of America's leading railroads.

Half a million miles on a diesel-electric locomotive in freight service is often the limit for standard coils. Yet, when the motor with National Silicone Mica-Glass insulated field coils and National Silicone Mica-Glas insulated armature was inspected in their shops after 509,454 miles in freight service, they report:

"The field coils look to be in perfect condition. No sign of working on the pole pieces. The field circuit meggers infinity and clears our hi-pot at 3,000 volts. The armature shows a slight chafing of 3 or 4 coils at the pinion end of the slot. Wedges appear to be in perfect condition and tight. We are returning the unit to a passenger locomotive for further road service."

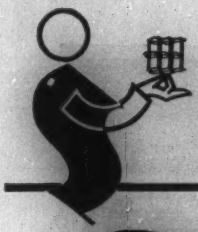
Everywhere in industry — steel, mining, central stations, railroads, manufacturing plants — National Silicone Mica-Glas insulation is setting new high performance records. If you want extra service from any rotating electrical equipment which faces an unusually rugged job, call in your nearby National field engineer. He'll bring you all the benefits of National experience — *first* in Silicone electrical application.

NATIONAL ELECTRIC COIL COMPANY

COLUMBUS 16, OHIO, U. S. A.

ELECTRICAL ENGINEERS — MAKERS OF ELECTRICAL COILS AND INSULATION

REDESIGNING AND REPAIRING OF ROTATING ELECTRICAL MACHINES

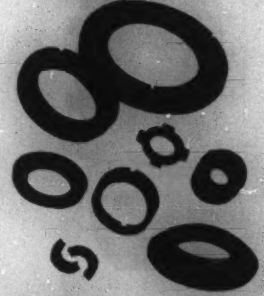


STACKPOLE

CARBON • GRAPHITE • MOLDED METAL

Engineering News

No. 5



NEW! SEAL RINGS FOR CORROSIVE CHEMICALS

Recent developments in Stackpole carbon-graphite shaft seal rings and washers include types that are highly effective in the pumping of acids and other corrosive chemicals. In addition, Stackpole offers unsurpassed facilities for engineering suitable grades for practically any requirement. Many grades are available and can be produced to suitable tolerances and specifically designed for operation against plates of bronze, brass, aluminum or other materials. Friction is greatly reduced and such unfavorable factors as tamping, packing and tightening are eliminated. Nor is there any danger of shaft abrasion when these composition seals are used!

Practically every application presents a different set of problems. Hence, Stackpole engineers welcome full details of your requirement on which their recommendations and sample seals or washers can be based. You be the judge!

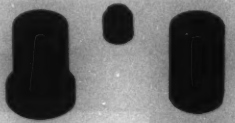
HERE'S SIMPLIFIED ULTRA-CRITICAL RESISTANCE OR VOLTAGE CONTROL

Continuously adjustable rheostats formed of piles of Stackpole carbon and graphite discs provide the ideal means of varying either resistance or voltage with maximum precision and smoothness simply by applying pressure to the piles. Applications range from generating equipment voltage regulators to line, speed and pressure regulators, continuously variable rheostats, pressure indicators and others. Recent Stackpole developments in this field include a special carbon-graphite mix which enables a single pile of only 39 discs to assure the high resistance needed for a sawing machine control previously involving two piles totalling 150 discs.

If you have a possible application, why not submit details to Stackpole for recommendation?

DASH POT PLUNGERS WITHOUT LIQUID LUBRICANTS

Few applications better illustrate the versatility of Stackpole graphite than its use for dash pot plungers—for the simple reason that the static friction of graphite against the smooth metal cylinder is not much greater than that of the sliding friction. No liquid lubricants which would be adversely affected by temperature changes are required. Thus the damping coefficient of a graphite plunger is determined almost entirely by the viscosity of the air itself. Stackpole facilities in this specialized field provide for the design and production of eminently satisfactory plungers for practically any dash pot need.

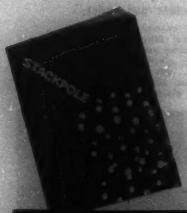


LOW-FRICTION BEARINGS

OF CARBON AND GRAPHITE

The use of self-lubricating bearings of carbon and graphite composition holds interesting possibilities for a wide variety of modern equipment. Units can be molded rather inexpensively to suitable tolerances and both the composition of the bearing mix and the shape of the finished piece can readily be designed for maximum efficiency. Beyond this, the graphite greatly decreases both friction and wear by coating *both* surfaces. Stackpole has achieved considerable success in this field and would like to tackle additional bearing problems where carbon and graphite compositions may hold the answers.

Why not send full details of your application for recommendation by Stackpole engineers?

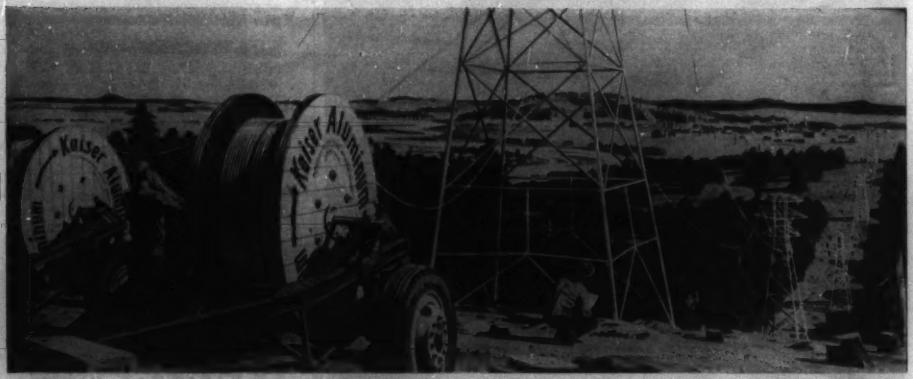


GET THIS HELPFUL CARBON-GRAPHITE SPECIALTIES BOOKLET

This 44-page, profusely illustrated book has been prepared to help you evaluate the possibilities of components of molded carbon, graphite and powdered metal composition in a broad range of modern equipment. Included are details on Stackpole tube anodes, battery carbons, ground rods, contacts, carbon piles, chemical carbons, friction segments, clutch rings, brazing and welding carbons, carbon molds and dies and many other products.

STACKPOLE CARBON COMPANY, St. Marys, Pa.

A major new source of Cable...



RIGHT NOW, Kaiser Aluminum Cable and ACSR is being delivered to public and private power enterprises—serving industry and farms—from coast to coast. Produced at Permanente Metals' strategically located Newark, Ohio plant—which has an annual capacity of more than 100 million pounds—this top-quality electrical conductor is available to you in a complete range of standard sizes and standard strandings.

brings more power to America!

KAISER ALUMINUM CABLE is tested by the most modern equipment in the country, including a new 100,000 pound, 50-foot tensile machine designed and built especially for Permanente Metals. Thus you are assured unsurpassed quality, at competitive prices. To take advantage of *some early delivery schedules which are still open,* act now. Inquire at any Permanente Products' sales office—in major cities from coast to coast.

Permanente Metals

PRODUCER OF

Kaiser Aluminum Cable

Completely Controlled for Quality

Permanente Metals' integrated operation completely controls the quality of Kaiser Aluminum Cable—from the processing of bauxite to finished cable.

Such quality control . . . plus a record for service that is unsurpassed . . . explains why thousands of manufacturers in many fields consistently use Kaiser Aluminum.

SOLD BY PERMANENTE PRODUCTS COMPANY, KAISER BLDG., OAKLAND 12, CALIFORNIA . . . WITH OFFICES IN:
Atlanta • Boston • Chicago • Cincinnati • Cleveland • Dallas • Denver • Detroit • Houston • Indianapolis • Kansas City • Los Angeles
Milwaukee • Minneapolis • New York • Oakland • Philadelphia • Portland, Ore. • Seattle • Spokane • St. Louis • Wichita

Also available through General Electric Supply Corporation, Westinghouse Electric Supply Company, and Line Material Company.

(*Continued from page 20A*)

mounting, the Faradon NF series, intended for use in low power transmitters for plate or grid coupling, filament, and plate bypass applications. Dimensions of these capacitors are $1^{15}/_{16}$ by 9/16 by $1^{3}/_{16}$ inches over all. Rating range is from .00005 microfarads with 2,500 d-c working volts to .03 microfarads with 600 d-c working volts. The new line also offers *JAN-C-5* quality, plus a hermetic seal in a molded low loss phenolic case. Additional information is available from the company.

GE Tube for Carried Current Application. A new tube, the *GL-5824*, developed by the Tube Divisions of the General Electric Company, has been designed to provide high power output at low plate and screen voltages in applications requiring long life and reliability. Physically and electrically it is interchangeable with the *25B6G;* improvements in the new tube over the *25B6G* include pre-aging for 50 hours to eliminate early operation failures, and improved series filament operation. The power amplifier pentode has plate dissipation of 12.5 watts with plate voltage at 200 volts. Heater voltage is 25 volts at 0.3 ampere. For additional information concerning the *GL-5824*, write to the General Electric Company, Electronics Park, Syracuse, N. Y.

General Purpose Relay. Specifically designed for a variety of applications, the new relay produced by Advance Electric and Relay Company, has six contact combinations available up to double pole, double throw, contacts on standard units $^{1}/_{4}$-inch diameter, pure silver, rated 115 volts alternating current or 24 volts direct current, non inductive. The relay is available for any operating voltage up to 300 direct current or 440 alternating current. Supplementary information is obtainable from the company at 1260 West 2nd Street, Los Angeles 26, Calif.

Low Price Transformers. The Audio Development Company, 2833 13th Avenue South, Minneapolis, Minn., has produced a new low price line of transformers, designated the Yeoman line, which incorporate the high standards of performance of the company's Quality Plus transformer series. The new line includes impedance matching, input, output, and power transformers in models for all applications. Additional information is found in the new Audio Development Company catalog, obtained upon request from the company.

TRADE LITERATURE

Oil Circuit Breaker Bulletin. The Pacific Electric Manufacturing Corporation, 5815 Third Street, San Francisco 24, Calif., has issued a new catalog on their type *RWE* oil circuit breaker, which has been designed for high-speed opening and reclosure of high-voltage transmission lines.

(*Continued on page 36A*)

OUTDOOR BUS INSTALLATION is exposed to extreme temperature, sunlight, moisture and corrosive gases. Yet the insulating material, "SCOTCH" No. 33 Electrical Tape, on the bars and leads is unaffected.

Get two-way protection with this NEW tape

The tough plastic backing on "SCOTCH" No. 33 Electrical Tape gives a high dielectric strength plus sturdy resistance to weathering and corrosion—making an efficient insulation for practically every type of electrical job.

Give this remarkable NEW "SCOTCH" Electrical Tape a try. You'll find it's easier to apply than other materials—gives you a neater, more compact job. Write Dept. EE-8 for complete information and a free sample.

Quick facts about "SCOTCH" No. 33 Electrical Tape

- **HIGH DIELECTRIC STRENGTH**—insulates perfectly against charges of over 7,000 volts.
- **TOUGH**—plastic backing resists abrasion, water, acids, alkalies, alcohols.
- **THIN CALIPER**—only .007" thick, requires less room in all insulation work.
- **STRETCHY**—conforms snugly to uneven surfaces, irregular shapes.
- Carries the seal of Underwriters' Laboratories.

Standard roll ¾ in. wide and 66 ft. long. Each roll individually packed in a handy tin.

ANOTHER 3M PRODUCT

Made in U. S. A. by

MINNESOTA MINING & MFG. CO., Saint Paul 6, Minnesota

General Export: DUREX ABRASIVES CORP., New Rochelle, N. Y.
In Canada: CANADIAN DUREX ABRASIVES LTD., Brantford, Ontario

Everything you need...

for Electrical Resistance Measurement

FROM .01 OHM UP TO 1000 MEGOHMS

In One "Megger"* Unit

Here is a combined "Megger" Insulation Tester and Wheatstone Bridge that has been proved by years of service, and that can be used to measure almost any resistance encountered in routine maintenance work—anywhere and at any time. It measures *conductor resistance* from as low as .01 ohm up to 999,990 ohms, and can be supplied with Varley Loop test facilities. It measures *insulation resistance* from 10,000 ohms to as high as 1000 megohms. A rotary switch permits instant selection between insulation resistance and Wheatstone Bridge functions. Having a self-contained hand generator, it is independent of batteries or outside source of power supply. Various ratings, 250, 500 or 1000 volts d-c. The set is portable, compact and simple to operate.

The "Bridge-Meg" Resistance Tester is fully described, fully illustrated in a 12-page bulletin available to you at no obligation. We would be pleased to send you a copy. Ask for Bulletin 21-60EE.

*REG. U. S. PAT. OFF.

JAMES G. BIDDLE CO.

Electrical & Scientific Instruments

1316 ARCH STREET, PHILADELPHIA 7, PA

SMALLER, LIGHTER, LESS EXPENSIVE

HIGH VOLTAGE D-C CAPACITORS

NOTE THE SIZES AND RATINGS!

Standard Vitamin Q Capacitors. Many special sizes and ratings also available.

Rated Cap. Mfds.	D-C† Rated Voltage	DIMENSIONS Width	Depth	Can Height	Terminal Height	Cat. No.
2.0	8000	8⅛	4⅛	6	2¼	25P51
4.0	8000	8⅛	4⅛	9¼	2¼	25P52
6.0	8000	8⅛	4⅛	13	2¼	25P53
10.0	8000	13½	4¼	13⅛	2¼	25P54
12.0	8000	13½	5¼	12¼	2¼	25P55
1.0	10000	8⅛	4⅛	5½	3 11/16	25P56
2.0	10000	8⅛	4⅛	8½	3 11/16	25P57
4.0	10000	13½	4¼	9¼	3 11/16	25P58
6.0	10000	13½	4¼	13⅛	3 11/16	25P59
8.0	10000	13½	5¼	12⅞	3 11/16	25P60
1.0	12500	8⅛	4⅛	7½	3 11/16	25P61
2.0	12500	8⅛	4⅛	12¼	3 11/16	25P62
4.0	12500	13½	5¼	11½	3 11/16	25P63
5.0	12500	13½	5¼	13¾	3 11/16	25P64
1.0	16000	8⅛	4⅛	10½	4 11/16	25P65
2.0	16000	13½	4⅛	12¼	4 11/16	25P66
3.0	16000	13½	5¼	13¾	4 11/16	25P67
1.0	20000	13½	4¼	11	4 11/16	25P68
1.5	20000	13½	5¼	12¼	4 11/16	25P69

†Capacitors with voltage ratings above 10 KV are recommended for upright mounting only. For mounting in other positions, please supply complete application data for recommendation by Sprague engineers.

USE an ordinary capacitor rated for 40°C. operation on a high-voltage d-c filtering circuit and chances are the higher temperatures encountered will necessitate a serious de-rating. In other words, you will have to buy a larger, heavier and costlier capacitor than you actually need.

Standard Sprague high-voltage capacitors impregnated with Vitamin Q, however, are rated conservatively for operation at 85°C. *They require no de-rating up to this temperature.* Special units can be supplied for continuous use up to 105°C.

These capacitors are consistently superior in their ability to maintain a high degree of capacitance-temperature stability. Power factor is outstandingly low over a wide temperature range; d-c insulation resistance is notably high; and a-c ripple voltage at audio frequencies falls well within permissible limits. Equally important, Vitamin Q impregnated capacitors have a high safety factor at all temperatures, thus assuring long life.

Write for Sprague Engineering Bulletin 203.

SPRAGUE VITAMIN Q* CAPACITORS

*Reg. U.S. Pat. Off.

SPRAGUE ELECTRIC COMPANY • NORTH ADAMS, MASS.

Average field service—
more than
a decade...

A 7,920 Kvar; 4,160 volt WYE, outdoor station-type C-D installation totalling 47,520 Kvar.

...and
still going
strong!

C-D

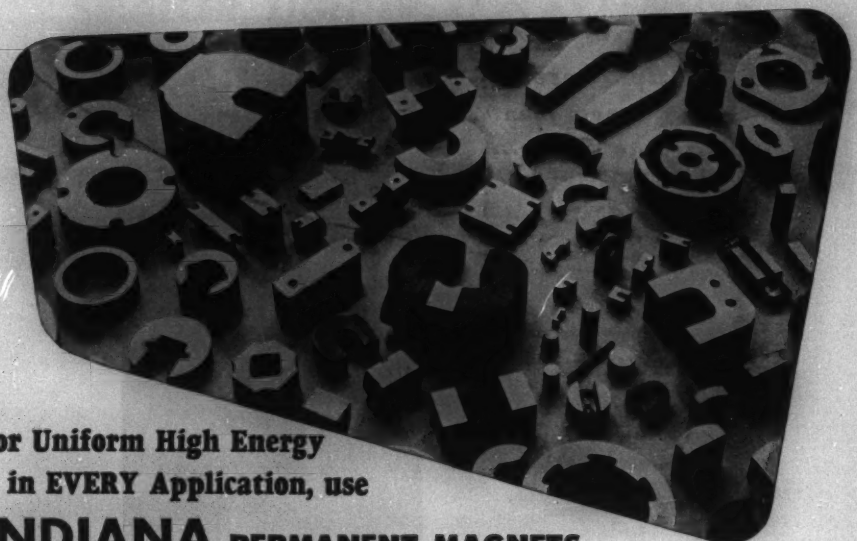
CORNELL-DUBILIER
CAPACITORS FOR POWER-FACTOR IMPROVEMENT

What goes into a C-D power-factor capacitor? The finest components and construction, of course... plus the "fourth dimensional" quality you can't see: the C-D "know-how" that comes from years of experience in building capacitors for power-factor improvement. That's why C-D installations remain in service for years—with little or no maintenance. And that's why leading utility engineers specify C-D. Consult your local C-D field engineer, or write for technical data to Cornell-Dubilier Electric Corporation, Dept. B89, South Plainfield, New Jersey. Other plants in New Bedford, Worcester, and Brookline, Mass.; Indianapolis, Ind.; Providence, R. I. and Cleveland, Ohio.

Follow the leaders
Demand dependable C-D Capacitors—built by capacitor specialists.

C-D Best by Field Test!

CORNELL-DUBILIER WORLD'S LARGEST MANUFACTURER OF CAPACITORS



For Uniform High Energy in EVERY Application, use

INDIANA PERMANENT MAGNETS

THIN-WALL ALNICO RINGS

All sizes of thin-wall, ring-type permanent magnets for television focus coils. Indiana quality assures a strong magnetic field.

"ION-TRAP" PERMANENT MAGNETS

Permanent magnets to deflect electrons out of the ion-electron stream. Made of Alnico and Cunife in all diameters and forms.

PERMANENT MAGNETS FOR PHONOGRAPH PICK-UPS

Indiana permanent magnets for transforming mechanical energy into electrical energy cover the full range of physical properties, sizes, and shapes. For phonograph pick-ups, microphones, electric organs, etc.

PERMANENT MAGNETS FOR SPEAKERS

Indiana permanent magnets for transforming electrical energy into mechanical energy in loud speakers, telephone receivers, polarized vibrators, electric clocks, etc. Indiana has the right permanent magnet for each need.

PERMANENT MAGNETS FOR INSTRUMENTS, RELAYS, AND CONTROLS

A complete variety for ammeters, galvanometers, light meters, voltage regulators, switches, polarized relays, etc. Indiana brings you the latest methods and techniques.

PERMANENT MAGNET SUB-ASSEMBLIES

Assemblies, of which the permanent magnet is a part, designed to meet your specifications. Furnished for all requirements.

● Look to INDIANA for *quality* permanent magnets—for skill in manufacture—for cost-cutting engineering aid. Strict supervision in every step of production is your assurance of exact magnetic and mechanical characteristics.

ALL MATERIALS • ALL SIZES • ALL SHAPES

INDIANA—the world's largest exclusive producer of permanent magnets, and the only manufacturer furnishing *all commercial grades* of permanent magnet alloys—has the know-how and facilities to develop and produce the permanent magnets you require. More than 30,000 different needs have been met successfully by INDIANA "packaged energy." Write today.

INDIANA'S wide variety of magnet alloys permits precise selection.

CAST
Alnico, I, II, III, IV, V, VI, XII
Cobalt
Cunico
Indalloy

SINTERED
Alnico II, IV, V
Indalloy
Vectolite

DUCTILE
Cunico
Cunife I, II
Silmanal

FORMED
Chromo
Cobalt
Tungsten

Sales Offices Coast to Coast

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Ask for Book No. 4A-89

INDIANA PERMANENT MAGNETS

THE INDIANA STEEL PRODUCTS COMPANY

VALPARAISO, INDIANA • • • Sales Offices Coast to Coast

SPECIALISTS IN "PACKAGED ENERGY" SINCE 1908

Oil Immersed

. . . . for dependable service and long life under adverse atmospheric conditions . . . .

AC MOTOR CONTROL
Across-the-line • Reduced Voltage • Reversing and Multi-Speed Starters
— combination or separate units.
2300V equipment of the cubicle construction
All of the above equipment is available in voltage ranges from 110 to 2300V
— 3-phase, 25 or 60 cycle.
Safety Disconnect Switches • Drum Switches
Spinner Motor Switches • Float Switches
Push Buttons • Lighting Switches
Most of the equipment listed above is available for Class I Group D locations.
Representatives' offices in principal cities throughout the United States • Facilities to design and manufacture control equipment to your engineering specifications.

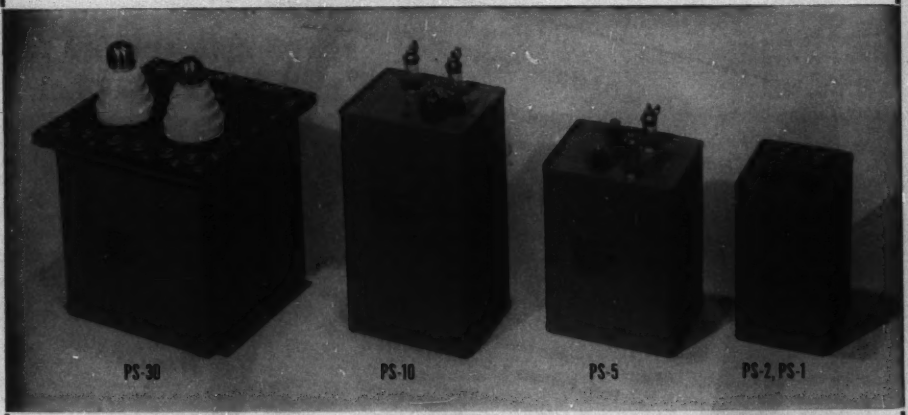
ROWAN CONTROL

THE ROWAN CONTROLLER CO., BALTIMORE, MD.

Introducing—

Another Plasticon Development

HIVOLT POWER SUPPLIES



HiVolt Supplies are self-contained in hermetically sealed metal containers. They are designed to transform low voltage AC to high voltage—low current DC.

PS-30-30,000 VDC, 1 Ma.; dimen. 7" x7" x 7"
PS-10-10,000 VDC, 2 Ma.; dimen. 3¾" x 4 9/16" x 8"
PS-5-5,000 VDC, 5 Ma.; dimen. 3¾" x 4 9/16" x 6"
PS-2-2400 VDC, 5 Ma.; dimen. 3¾" x 3 3/16" x 5½"
PS-1-2400 VDC—Capacitor load; dimen. 3¾" x 3 3/16" x5½"

High Voltage-Low Current DC Power Supplies

for

Television — Radiation Counters — Photo-flash Devices—Electrostatic Precipitators—Spectrographic Analysers—Oscilloscopes, etc.

Write for descriptive literature

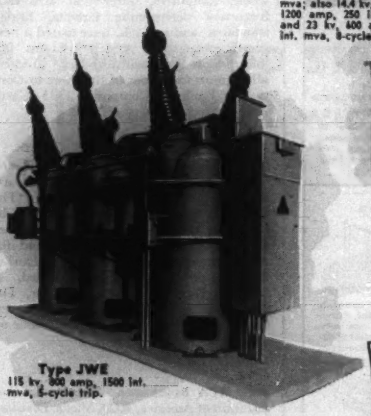
Plasticon Capacitors, Pulse Forming Networks and HiVolt Power Supplies are available at all leading jobbers.

Condenser Products Company

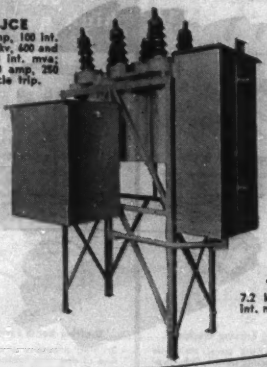
1375 NORTH BRANCH STREET • CHICAGO 22, ILLINOIS

OIL CIRCUIT BREAKERS

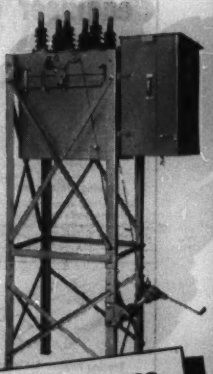
for Outdoor High-Voltage Stations . . .



Type JWE
115 kv, 500 amp, 1500 int. mva, 5-cycle trip.



Type JCE
14.4 kv, 600 amp, 100 int. mva; also 14.4 kv, 600 and 1200 amp, 250 int. mva; and 23 kv, 600 amp, 250 int. mva, 8-cycle trip.



Type AKE
7.2 kv, 600 amp, 50 int. mva, 8-cycle trip.

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All Pacific breakers, large and small, embody the **same** time-tested design elements:

(1) **Motor-Compressed-Spring Stored-Energy Operating Mechanisms** assure identical opening and closing times, regardless of frequency of operation.

(2) **Arc-Expulsion Chambers** with directed gas blast extinguish arcs without appreciable rise of tank pressure or burning of contacts.

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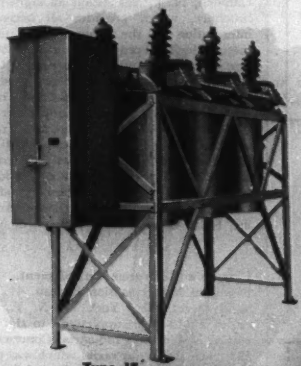
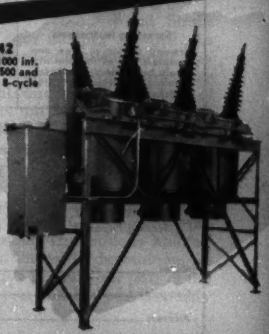
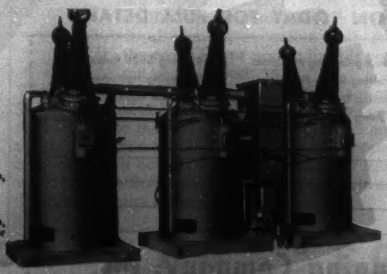


Type JE
23 kv, 1200 amp; 34.5 kv, 600 amp, both 500 int. mva; and 34.5 kv, 1200 amp, 1000 int. mva; also 46 kv, 600 amp, 500 int. mva, and 1200 amp, 1500 int. mva, 8-cycle trip.



Type JE-42
69 kv, 600 amp, 1000 int. mva; 1200 amp, 1500 and 2500 int. mva, 8-cycle trip.



Type RWE
115 kv, 138 kv, and 161 kv, 1200 amp, 3500 int. mva, 5-cycle trip.

Type RHE
Is similar, for 138 to 230 kv, 800 amp, 5000 int. mva; or 1200 amp, 7500 or 10,000 int. mva, 3-cycle trip.

AIEE and NEMA Standards

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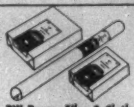

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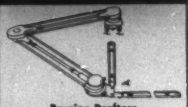

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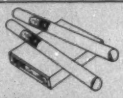
These machines combine T-square, scales, straight-edge, triangle, and protractor into one precision instrument. They save up to 40% in time.



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(*Continued from page 28A*)

The catalog contains full descriptions, specifications, and cutaway diagrams of the circuit breaker. Copies are available from the company.

Plasticon Specification Sheet. Condenser Products, manufacturers of laboratory-grade Plasticon capacitors, used for electronic computers, differential analyzers, frequency determining circuits, bridge standards, and so forth, have issued a new specification sheet, which contains full information on their product. Address all requests for copies of the sheet to Condenser Products Company, 1375 North Branch Street, Chicago 22, Ill.

"The Hubbard Linebuilder." Issued monthly by the Electrical Materials Department of Hubbard and Company, "The Hubbard Linebuilder" is a booklet published for the purpose of linking together the ideas of the users of pole line and distribution materials with the manufacturing facilities and products of Hubbard. A letter to Norman E. Sharp, Editor, The Hubbard Linebuilder, 6301 Butler Street, Pittsburgh 1, Pa., will place your name on the mailing list.

New RCA Brochures. The Radio Corporation of America, RCA Victor Division, Camden, N. J., has issued an eight-page brochure, which provides all necessary information on the company's 35 millimeter television projector, and four other new brochures which describe RCA's latest developments in frequency modulation equipment: "FM Broadcast Transmitter, *BTF-5A;* "FM Broadcast Transmitter; *BTF-50A*", "Universal Transmitter Control Console," and "AM-FM Isolation Unit." Those desiring copies of the above brochures should address requests to the Engineering Products Department, Radio Corporation of America, RCA Victor Division, Camden, N. J.

Lincoln's Reference Supplement. The Electrical Modernization Bureau, 41 East 42nd Street, New York 17, N. Y., has issued a 113-page supplement to the first edition of Lincoln's Industrial-Commerical Electrical Reference book, which was published in 1941. Copies of the supplement are being sent free of charge to all registered owners of the book, and any book owner who doesn't receive his copy should notify the Bureau, giving his correct address and the number of his book. The second edition of Lincoln's Electrical Reference, now in preparation, will be published early in 1950.

New Edition of "Chance Tips." Volume II, Number 2, of "Chance Tips," published by the A. B. Chance Company, 210 North Allen Street, Centralia, Mo., has just come off the press, containing articles on anchor installation, the Chance KM Cutout, and

(*Continued on page 48A*)

Once Again

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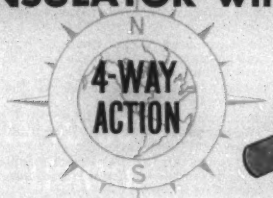
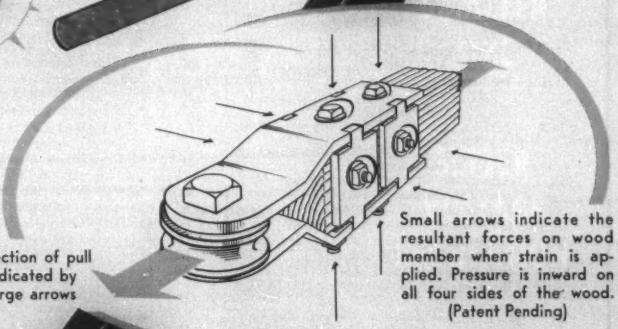
A NEW WOOD STRAIN INSULATOR with





Direction of pull indicated by large arrows

Small arrows indicate the resultant forces on wood member when strain is applied. Pressure is inward on all four sides of the wood. (Patent Pending)

As tension is applied to the new Hubbard Wood Strain Insulator, the interlocking plates start moving forward. As they move slightly, the inclined planes under the heads and nuts of the assembly bolts cause a simultaneous motion inward, 90 degrees to the line of pull, and on all four sides of the wood member. In older designs the "squeeze" has been applied transversely in two opposing directions only, which results, under excessive pull, in a crushing and "flowing" of the wood fibres until a limit is reached where the bolts shear out of the wood.

With the Hubbard 4-way design, the "squeeze" is from all four sides. There is no relief area into which the wood can "flow." Consequently, the fittings hold to the full strength of the wood member. Tremendous holding power has been achieved by this development. Pulled to destruction, no fractures have occurred under a fitting but always in the clear part of the wood. For the first time, a wood strain insulator is available with perfectly designed fittings and at a low cost.

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Standards on electric machinery and apparatus chiefly devoted to defining terms, conditions and limits which characterize behavior, with special reference to acceptance tests.

A discount of 50 per cent, on single copies is allowed to Institute members except as noted. Such discount is not applicable on extra copies unless ordered for other members.

1	General Principles Upon Which Temperature Limits are Based in the Rating of Electric Machines and Apparatus (June 1947)	$ 0.80
1B	Report on Guiding Principles for Specification of Service Conditions (May 1944)	.40
3	Guiding Principles for Selection of Reference Values for Electrical Standards (Oct. 1943)	.60
*4	Measurement of Test Voltage in Dielectric Tests (Nov. 1942) (ASA C68.1)	.80
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*17†	Mathematical Symbols (Jan. 1928) (ASA Z10.0)	.40
20	Air Circuit Breakers (May 1930)	.60
20A	Low-Voltage Air Circuit Breakers (Dec. 1946) (Published for trial use as a proposed revision of No. 20 No charge for copies)	
*21	Apparatus Bushings (July 1943) (ASA C76.1)	.60
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600	Recommended Specification for Speed Governing of Prime Movers Intended to Drive Electric Generators (May 1949)	.60
{601} {602}	Preferred Standards and Standard Specification Data for Large 3600-rpm, 3-Phase, 60-Cycle Condensing Steam Turbine Generators (May 1949)	.60
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*C57	Transformers, Regulators and Reactors (May 1948)	4.00
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8-49

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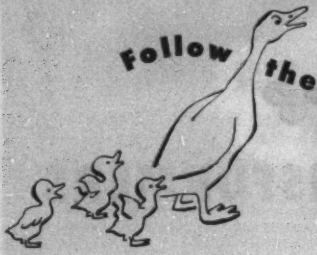

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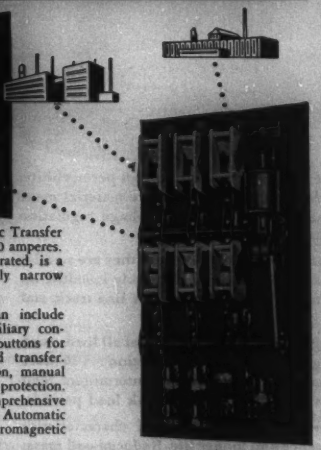

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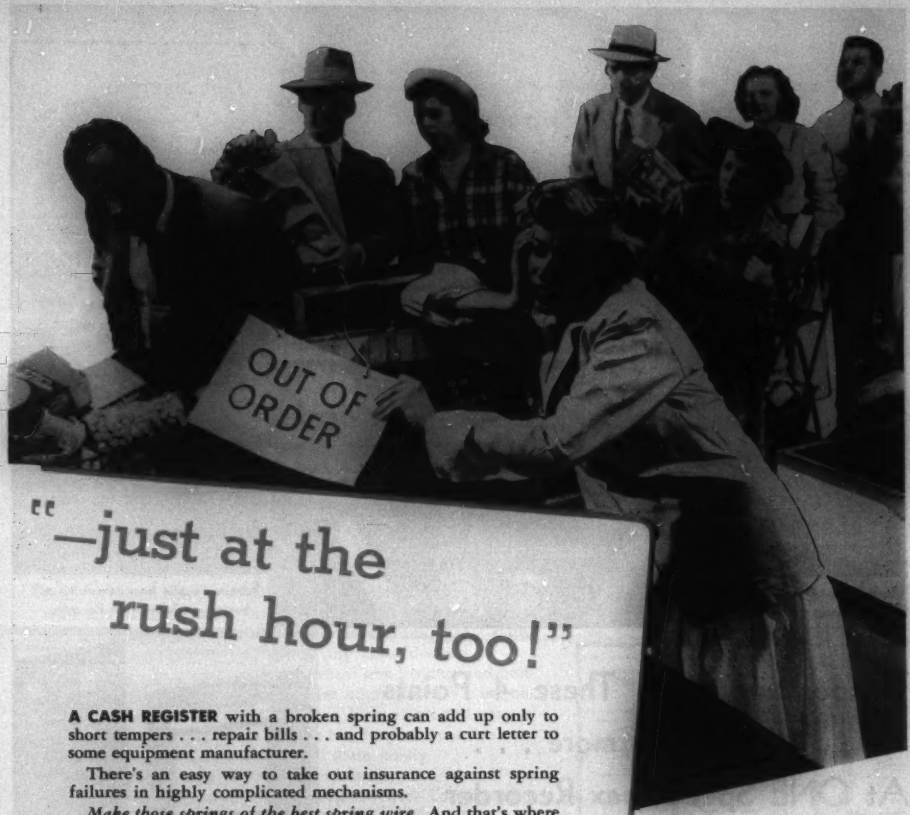

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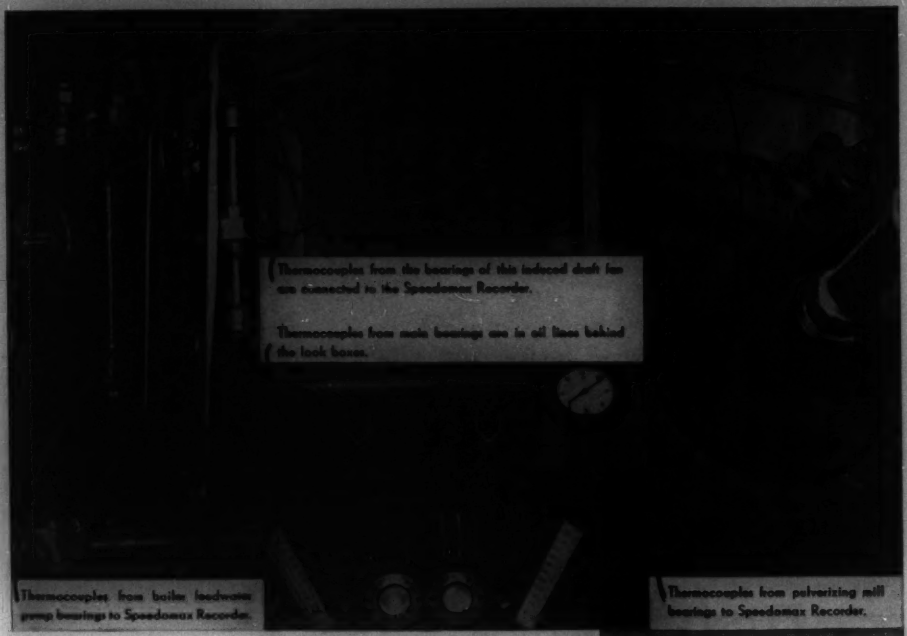
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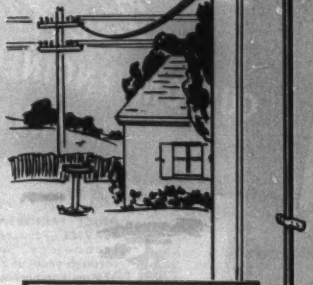

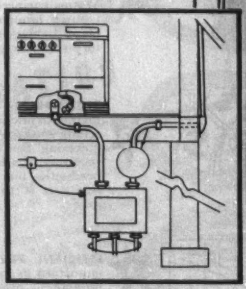

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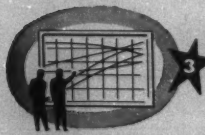

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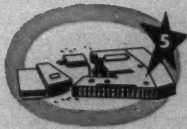

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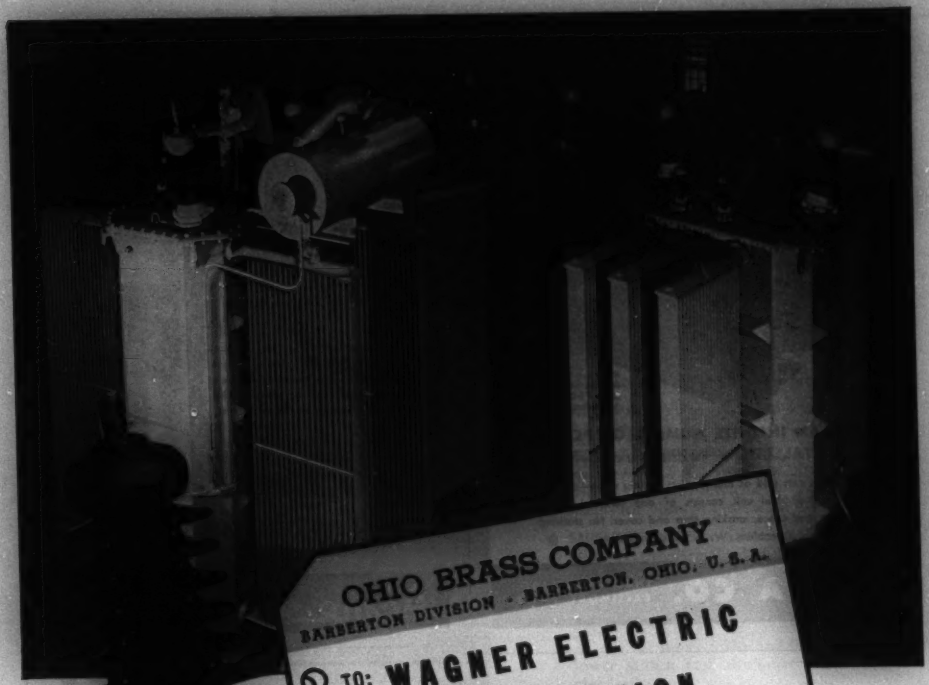

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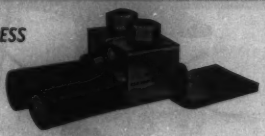

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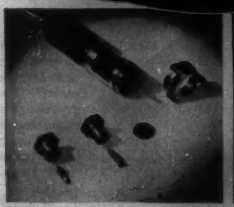

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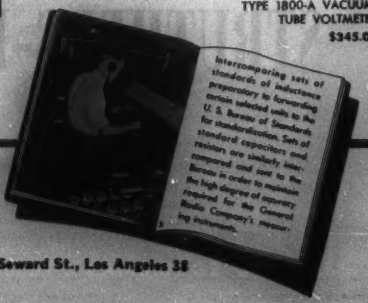
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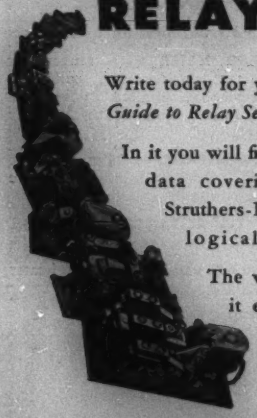

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Continued from page 36A)

hot pole top change-cutouts to switches. Copies of the magazine may be obtained by writing to the company.

Electrical Lugs and Connector Manual. Ilsco Copper Tube and Products, Inc., has just published an 80-page manual which contains technical data, engineering information, photographs, dimensions, ampere ratings, and other material essential for production and maintenance on electrical lugs and connectors. Copies are available from the company, Ilsco Copper Tube and Products, Inc., Mariemont, Cincinnati 27, Ohio.

Allis-Chalmers Bulletins. Allis-Chalmers Manufacturing Company, 931 South 70th Street, Milwaukee, Wis., has released two new publications: "The Inside Story of Allis-Chalmers 'Safety-Circle' Motor Protection," *51B6210B*, and "Allis-Chalmers Oil Circuit Breakers," *71B60220*. Both are available upon request to the company.

Westinghouse Single Drive Motor Booklet. Information concerning the Westinghouse regulated single motor drive for paper machines is contained in a recent booklet put out by the company. Copies are obtainable upon request from the Westinghouse Electric Corporation, Box 868, Pittsburgh 30, Pa.

Super Coronol Aerial Cable Booklet. The Construction Materials Department of the General Electric Company, Bridgeport 2, Conn., has just released a 26-page bulletin, number *GEA-5157*, "Super Coronol Aerial Cable—Preassembled and Field Assembled," devoted to technical instructions concerning selection and installation, splicing and terminating of aerial cables. Copies are available from the company.

"For Practical Men." The James G. Biddle Company emphasizes preventative insulation maintenance in a new 24-page pamphlet, Bulletin *21P8-7*, entitled "For Practical Men," and offers instructions for making insulation resistance measurements with a "Megger" insulation tester. Copies may be obtained by writing to the James G. Biddle Company, 1316 Arch Street, Philadelphia 7, Pa.

AN Desk Chart. Cannon Electric Development Company, Catalog Department, 3209, Humboldt Street, Los Angeles 31, Calif., has issued a new desk size Army-Navy connector specifications chart with the latest insert arrangements shown in detail at half scale for use by aircraft, radio, communication engineers, designers, maintenance men, and purchasing agents. The chart, *AN-C-591*, measures 17 by 22 inches and contains 203 insert-layouts, and many additional insert positions, together with information as to latest service voltages, alternate insert positions and other data. A full scale chart, 38 by 50 inches is also available upon request to the company.

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PROFESSOR OF COMMUNICATIONS ENGINEERING needed for Fall 1949 by Southeastern University. Will be in charge of graduate work and research activities. $6000 for nine months with extra income for summer teaching. Must have Ph.D. or D.Sc. degree. Address: Box 735, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

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ASSISTANT PROFESSOR of electrical engineering, Doctor's degree preferred, with primary interest in the power field. Salary $4500.00 for nine months. Location: Southwest. Address: Box 825, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

TECHNICAL WRITER: An opportunity for an experienced technical writer. Preferably an electrical engineering graduate with experience in the field of electronic development. Research Laboratory located adjacent to Washington, D. C. Salary commensurate with experience. Address: Box 826, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

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ELECTRICAL ENGINEER, young, to act as assistant to chief electrician for general electrical work, mostly maintenance. Company maintains three hydro-electric and one diesel power plant. Will supervise native crews. Must speak Spanish. Salary, $3600 a year, plus board, room and transportation for a single man; if married, must report single status for four months after which time he will be given a $65 a month board allowance, plus a furnished house and utilities. Two-year contract. Location, Central America. Y-2510.

PROJECT ENGINEER, electrical graduate, with advanced degree and considerable design and development experience for circuit analysis and development covering analogue computers. Salary, $6000–$7000 a year. Location, New York, N. Y. Y-2513.

INDUSTRIAL ENGINEER, 30–45, graduate, I.E., E.E. or M.E., with experience in the metal industry or in the management consultant line, including preparation of organizational charts, reviewing department duties and responsibilities and preparing concise definitions; preparing job breakdown for department manuals for clerical and supervisory positions; preparation of flow charts, recommended improvements in procedures for increased efficiency and experience in setting office standards desirable. Salary open, commensurate with qualifications. Location, Connecticut. Y-2517.

ENGINEERS with M.S. or Ph.D. degrees and several years' professional experience; advanced degrees in physics and an interest in electronics or servo engineering particularly desirable. (a) Duties of the electronics engineers include development of electronic circuits, microwave components, UHF and VHF antennae, and the analytical study of electric circuits and complex electronic systems. (b) Duties of the servo engineers include development of electronic control circuits, high performance servo actuators and automatic computers, and the analytical study of dynamical systems, aerodynamic control techniques and computing equipment. (c) Duties of the mathematicians include applied mathematics in the fields of dynamics, stress, fluid flow, circuit analysis, etc. Location, Washington State. Y-2531.

ELECTRONIC ENGINEER, 28–40, college education specializing in electrical engineering, with four to seven years' experience working with electronic circuits, particularly low-frequency amplifiers, low-pass filter limiters, trigger circuits and thyratron control. Industrial electronic control experience preferred but not essential. Will be responsible for all design of electronic components used in special recording apparatus and test equipment of complex nature; supervision of layout and detailed drawings; check performance of pilot models and render reports calculated to improve operation or construction; analyze existing patents and make recommendations; prepare patent applications based on inventive ingenuity. Will work on broad assignments subject to check upon completion. Salary, $5440–$6480 a year. Location, Connecticut. Y-2535.

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Apply by letter addressed to the key number and mail to New York Office. When making application for a position include six cents in stamps for forwarding application to the employer and for returning when necessary. A weekly bulletin of engineering positions open is available to members of the co-operating societies at a subscription rate of $3.50 per quarter or $12 per annum, payable in advance.

Men Available

ELEC ENGR, June 1949 grad. Diligent, capable; age 22; free to travel; relocate. Desires pos which will lead to career in sales engg or admin work. E-432.

ELEC ENGR, B.E.E.; age 27; 1½ yrs elec util exper; knowl pwr distr and protective eqpt; 3 yrs machine shop exper. Desires pos with manufacturer. E-433.

ENGR-EXEC. Regis prof engr; 25 yrs broad util and indus exper. Opern, construction, management, budgets, forecasts, rates, public and employee relations. Seeks admin pos management staff. Anywhere except South. E-434.

ELEC ENGR, B.S.E.E.; 39, married; 5 yrs pwr; 5 yrs indus control electronics, resistance welding; 4 yrs devpmt project engr; supervision instrumentation—tests; creative. Desires exec, research sales. Location, eastern Penna. E-435.

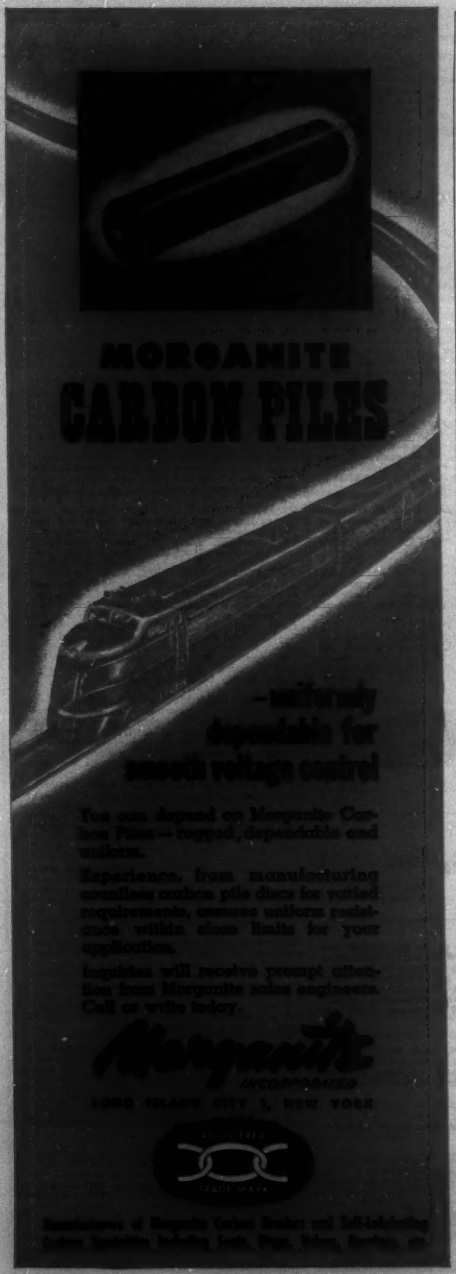
ELEC ENGR, B.S., June 1949; single, 24; Sigma Xi, former Navy Electronics Mate; prefers pos as jr engr in electronics, U.H.F., or pwr trans. Research work in above welcomed. Location, East. E-436.

ENGR-EXEC, B.S.E.E., Purdue; 8½ yrs engr sales engr major motor control mfr; 2 yrs office and service mgr; 1½ yrs engr Navy submarine control. Desires admin or sales. Vicinity New York. E-437.

ELEC ENGR, B.S.E.E.; 14 mos television lab exper; 26 mos telephone project and specification work. Tau Beta Pi. M.S. Feb. 1950. New York area preferred. E-438.

JR ELEC ENGR, grad August 1949; member Tau Beta Pi, Eta Kappa Nu. Prefers work out of country. Hard worker, thorough, dependable. E-439.

REC GRAD of CIT with M.S. in E.E.; desires employment in automatic control circuits and servomechanism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Experience, from manufacturing countless carbon pile discs for varied requirements, assures uniform resistance within close limits for your application.
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INDEX TO ADVERTISERS

Acme Electric Corp. 46 A
AIEE Special Publications 40 A
AIEE Standards 38 A
Allegheny Ludlum Steel Corp. 12 A
Allis-Chalmers Manufacturing Co. 2nd cover, 22 A–23 A
Anaconda Wire and Cable Co. 6 A
Arnold Engineering Co. 24 A
Automatic Switch Co. 40 A

Bell Telephone Laboratories 21 A
Bethlehem Steel Co. 19 A
Biddle Co., Jas. G. 29 A
Bruning Co., Inc., Chas. 36 A

Classified Advertising 51 A
Cole Electric Co. 54 A
Condenser Products Co. 34 A
Cornell-Dubilier Electric Corp. 31 A

Dow Corning Corp. 16 A

Fasco Industries, Inc. 44 A

General Electric Co. 8 A–9 A
General Radio Co. 47 A
Gibson Electric Co. 53 A

Hazard Insulated Wire Works 5 A
Hubbard and Co. 37 A

Ilsco Copper Tube and Products Co., Inc. 46 A
Indiana Steel Products Co. 32 A
Industrial Notes 16 A, 20 A, 28 A, 36 A, 48 A
Insulation Manufacturers Corp. 4 A
I-T-E Circuit Breaker Co. 3rd cover

Kerite Co., The 13 A

Leeds and Northrup Co. 42 A
Locke Insulator Corp. 7 A

Macmillan Co., The 50 A
Minnesota Mining and Manufacturing Co. 28 A
Moloney Electric Co. 39 A
Morganite, Inc. 52 A

National Electric Coil Co. 25 A, 40 A

Ohio Brass Co. 45 A
Ohmite Manufacturing Co. 18 A

Pacific Electric Manufacturing Co. 35 A
Permanente Metals Corp. 27 A
Personnel Service, Inc. 51 A
Power Equipment Co. 20 A
Professional Engineering Directory 50 A

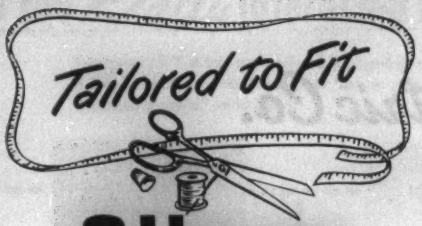
Radio Corporation of America 4th cover
Rome Cable Corp. 43 A
Rowan Controller Co., The 33 A

S and C Electric Co., Inc. 14 A–15 A
Sig-Trans, Inc. 46 A
Simplex Wire and Cable Co. 49 A
Sprague Electric Co. 30 A
Stackpole Carbon Co. 26 A
Struthers-Dunn, Inc. 48 A

Trumbull Electric Manufacturing Co. 17 A

United States Steel Corp. 10 A–11 A, 41 A
Universal Clay Products Co. 46 A

Vickers Electric Division 50 A, 53 A
Wama Company 46 A
Westinghouse Electric Co. 2 A



Gibson

Electrical Contact Assemblies

Are furnished in THREE ways to suit your particular needs

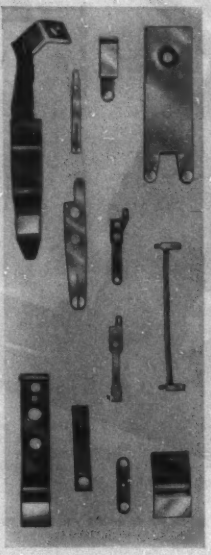
Gibson Electric Company can supply you with *complete* contact assemblies, made to your specifications, and with both contacts and supports supplied by us.

OR—

Gibson will attach our contacts to supports supplied by you. Our plant is fully equipped to rivet, braze, or weld contacts to any type of contact support.

OR—

Gibson will furnish you, for assembly in your own plant, contacts of any type, including rivets, solder back contacts for brazing, and projection back contacts for welding. Projection back contacts include solid contacts as well as composite contacts having a backing of nickel plated steel or other weldable base metal. GIBSON electrical contacts are made from fine silver, coin silver, Gibson silver alloys, and Gibsiloy powdered metal materials.



Regardless of the type of service you use—

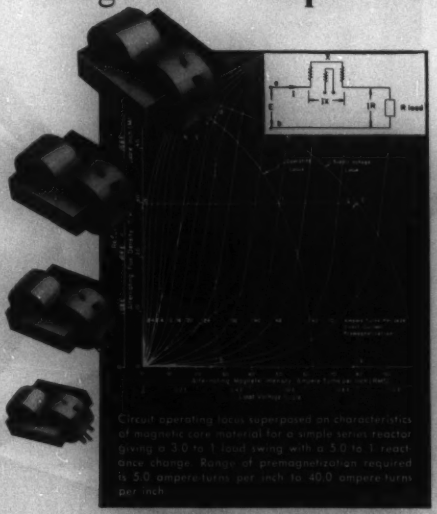
Gibson engineers are available to advise you on the best materials and best methods for making electrical contact assemblies. This service is offered at no extra cost—whether you order complete contact assemblies or simply order contacts for assembly in your own plant. Gibson recommendations are backed by years of experience in manufacturing electrical contacts and contact assemblies to suit any application. Write for complete details.

Gibsiloy ELECTRICAL CONTACTS — Manufactured by GIBSON ELECTRIC COMPANY — Frankstown Ave., Pittsburgh 21, Pa.

MARK OF PROGRESS... IN ELECTRICAL PRODUCTS

VICKERS ELECTRIC DIVISION

Of Vital Interest to the Electrical Industry... Vickers Magnetic Amplifiers



Circuit operating locus superposed on characteristics of magnetic core material for a simple series reactor giving a 3.0 to 1 load swing with a 5.0 to 1 reactance change. Range of premagnetization required is 5.0 ampere-turns per inch to 40.0 ampere-turns per inch

VICKERS ELECTRIC DIVISION, Vickers Inc., offers complete, extensive *Research*, *Engineering* and *Development* facilities which are available to the industry for technical problems and applications of VICKERS products relative to specific requirements.

MAGNETIC AMPLIFIERS • STATIC VOLTAGE REGULATORS • STATIC MOTOR SPEED CONTROLS • POWER SATURABLE REACTORS RECTIFIERS • PHOTOELECTRIC CELLS • SERVOMECHANISMS MAGNETIC FLUID CLUTCHES • SPECIAL MOTORS AND GENERATORS TRANSFORMERS • CONTROLLED POWER RECTIFIERS FOR ELECTRO-CHEMICAL PROCESSES

Request Magnetic Amplifier Bulletin VT-2000

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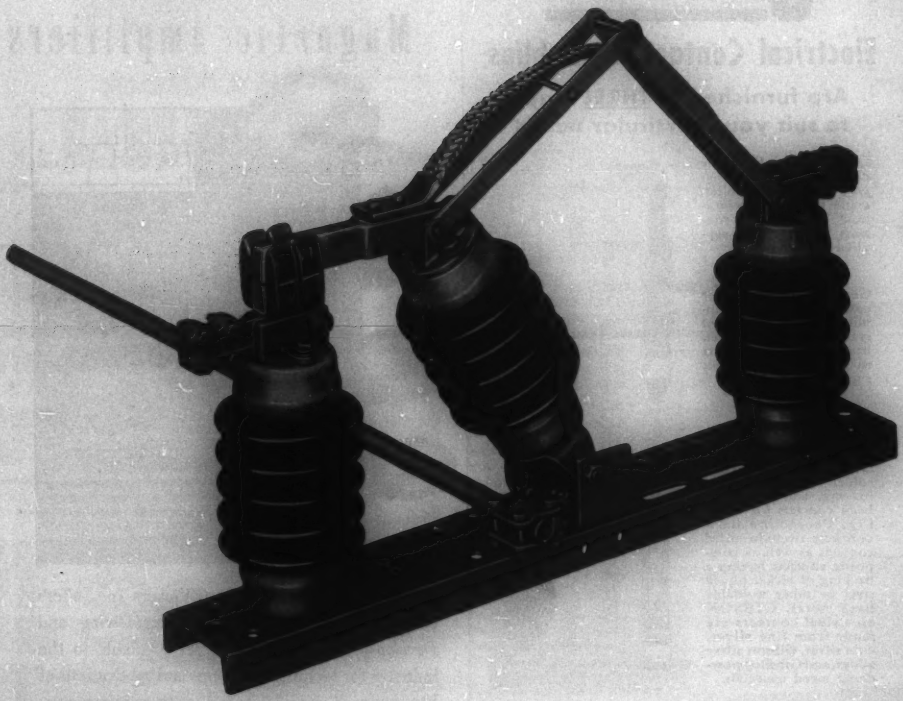


OUTDOOR DISCONNECTING SWITCH

Vertical Break; 15 KV.—400 Ampere

3 Pole—Single throw—Group operated

One Pole Shown

See Bulletin 33A

Are You *Really* Interested in Getting More for Your Money?

For years, I-T-E has maintained leadership in the circuit breaker and switchgear industry. Today, I-T-E invites you to look over the special built-in features which have become a part of its "standard price" switchgear . . .

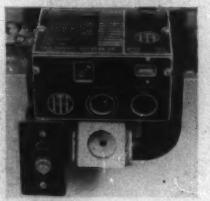
Planned for better
ACCESSIBILITY

METERS AND RELAYS are mounted on a *Relay Panel* designed for that specific purpose. Why?

a. Delicate relay mechanisms are not subjected to "operation by vibration" when circuit breaker doors are opened or closed or bumped.

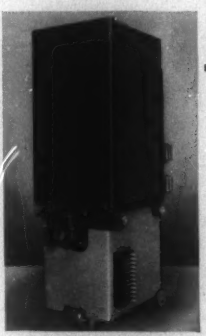
b. The Relay Compartment is just that. The secondary wiring, control bus, and relays are together, *where you want them,* not where manufacturing economy dictates.

Planned for easier
HANDLING

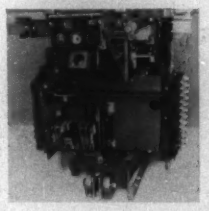


TESTING CIRCUIT BREAKER operation within the structure is no longer a chore.

a. Release a catch, move the breaker 4½ inches, and you are ready to test. An electrical close-trip test-switch is furnished on every breaker unit. Test control circuits are automatically set up. No jumpers, no plugs, no push, no pull. Easy does it!



Planned for greater
SAFETY

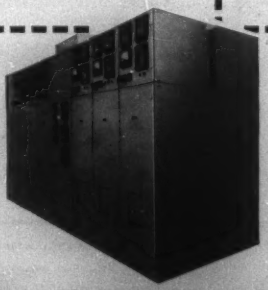


HIGH IMPULSE CIRCUIT BREAKERS

If you are impulse conscious you are familiar with the present interim test that permits circuit breakers of the 5KV class to be subjected to a 45KV impulse test across the open contacts. Type HV breakers are tested to withstand arc 60KV impulse — phase to phase, phase to ground, and across the open contacts.

COORDINATED IN MULTUMITE BOARDS

I-T-E HV MULTUMITE Switchgear assemblies coordinate efficient I-T-E HV Air Circuit Breakers with transformers, meters, bus, and instruments into a single, efficient unit. I-T-E HV Air Circuit Breakers are rated at 5KV, 7.5KV, and 15KV — 600 A., 1200 A., and 2000 A. continuous; 50MVA, 150MVA, and 250MVA interrupting.



These are but a few of our better points. There is an I-T-E Field Application Engineer in your area. Permit him to tell you of other advantages, and to assist in your switchgear planning.

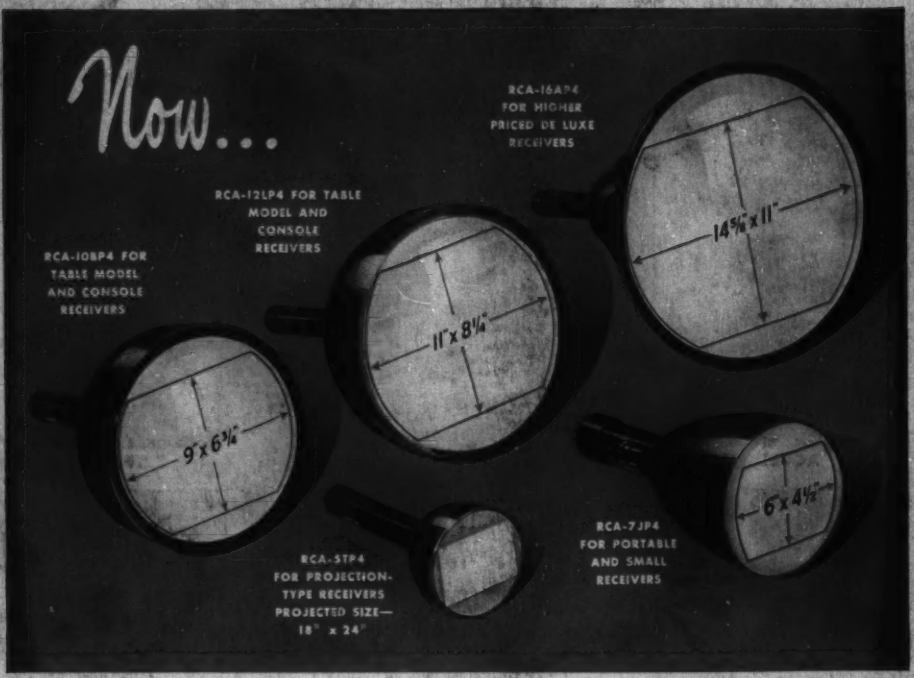
I-T-E R&IE

POWER SWITCHGEAR

I-T-E CIRCUIT BREAKER COMPANY, 19th & Hamilton Streets, Philadelphia 30, Pa.
31 Offices in United States · In Canada, EASTERN POWER DEVICES, Ltd., TORONTO
For Export: Philips Export Corp., New York

SWITCHGEAR • UNIT SUBSTATIONS • ISOLATED PHASE BUS STRUCTURES • POWER CIRCUIT BREAKERS
MECHANICAL RECTIFIERS • RESISTORS • SPECIAL PRODUCTS

* For power switching equipment refer to Railway & Industrial Engineering, an I-T-E organization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14 5/16" x 11"
RCA-12LP4 FOR TABLE MODEL AND CONSOLE RECEIVERS
11" x 8 1/4"
RCA-10BP4 FOR TABLE MODEL AND CONSOLE RECEIVERS
9" x 6 3/4"
RCA-5TP4 FOR PROJECTION-TYPE RECEIVERS PROJECTED SIZE— 18" x 24"
RCA-7JP4 FOR PORTABLE AND SMALL RECEIVERS
6" x 4 1/2"

THE FOUNTAINHEAD OF MODERN TUBE DEVELOPMENT IS RCA

. . . the five most popular kinescopes ___from one dependable source

RCA now has a popular type of kinescope to accommodate television receiver designs in practically every class and price range.

Concentrated production on these five accepted types results in longer production runs, which in turn, make possible lower cost, more uniform, and better quality tubes for our customers.

All five types are currently being mass-produced at the famed RCA tube plant in Lancaster, Pennsylvania. In addition, a large new plant is under construction at Marion, Indiana, where the production will be centered on the RCA-16-inch metal-cone kinescope.

RCA Application Engineers are ready to cooperate with you in applying these kinescopes and their associated components to your specific designs. For further information write RCA, Commercial Engineering, Section 39HR, Harrison, N. J.

RCA **RADIO CORPORATION of AMERICA**

ELECTRON TUBES **HARRISON, N. J.**